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**ABSTRACT:**


CHG DATE=19990617 STATUS=O>A process for producing a single crystal layer from amorphous or polycrystalline semiconductor material on an amorphous foreign substrate involves forming a nucleation centre point by laser melting with a single laser pulse of preset spot size and then linearly advancing a resulting solidified small crystallisation front by alternate steps of changing of the radiation location in the submicron range and emitting further laser pulses. The novelty comprises a further process stage of (a) matching the laser pulse spot size (9) to the long edge length (8) of the elongated single crystal (6) formed in the preceding stage; and (b) linearly advancing one or both long edges of the crystal as a broad

crystallisation front (10) by alternate steps of changing of the radiation location in the submicron range and emitting further laser pulses (3) having the broadened spot size (9). Also claimed is an apparatus for carrying out the above process.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the semiconductor device which makes an active region the crystalline silicon film which crystallized the amorphous silicon film in the detail, and its manufacture approach further about a semiconductor device and its manufacture approach. Especially this invention is effective in the semiconductor device which prepared the thin film transistor (TFT) prepared on the substrate which has an insulating front face, and can be applied to the liquid crystal display of a active-matrix mold, a contact type image sensor, a three-dimensional IC, etc.
[0002]
[Description of the Prior Art] In order to realize the contact type image sensor of high resolution, a three-dimensional IC, etc. at the liquid crystal display of high resolution, and a high speed in recent years, the attempt which forms a highly efficient semiconductor device in tops, such as insulating substrates, such as glass, and an insulator layer, is made. It is common to such a semiconductor device to use a thin film-like silicon semi-conductor. It is divided roughly into two, an amorphous silicon semi-conductor (a-Si) and the silicon semi-conductor which has crystallinity, as a thin film-like silicon semi-conductor.
[0003] An amorphous silicon semi-conductor has low manufacture temperature, since it can produce comparatively easily by the gaseous-phase method, is excellent in mass-production nature, and, most generally is used. However, since an amorphous silicon semi-conductor is inferior in physical properties, such as a dielectric, as compared with the silicon semi-conductor which has crystallinity, the establishment of the simple manufacture approach of a silicon semi-conductor which has the crystallinity which can acquire the further high-speed property will be called for strongly from now on.
[0004] As an approach of manufacturing the silicon semi-conductor which has crystallinity, the approach shown in the following (1) and (2) is learned.
(1) Irradiate energy beams, such as a laser beam, at the amorphous silicon semi-conductor film, and consider as the silicon semi-conductor film which crystallizes the amorphous silicon semi-conductor film and has crystallinity with the light energy, after forming the amorphous silicon semi-conductor film.
(2) Heat and consider as the silicon semi-conductor film which crystallizes the amorphous silicon semi-conductor film and has crystallinity with the heat energy, after forming the amorphous silicon semi-conductor film.
[0005] Generally, the approach of the above (1) is used. Although crystal grain serves as a diameter of a granule by this approach in order to use the crystallization phenomenon of a melting solidification process, there are few crystal defects in crystal grain, and the comparatively quality crystalline silicon semi-conductor film is obtained. However, by the crystalline silicon semi-conductor film produced by the approach of the above (1), since the defect density in the grain boundary section becomes high, the defect in this grain boundary section works as a big trap to a carrier, and engine performance sufficient as a semiconductor device is not obtained. Moreover, since laser light stability is not enough when use the excimer laser currently present most generally as the light source of laser light use, for example, it is not easy to perform uniform processing over the whole surface of a substrate, and it cannot form two or more crystalline silicon semi-conductor film which has a uniform property on the same substrate, but there is a possibility that dispersion in a property may arise between semiconductor devices.
[0006] Although the approach of (2) is excellent in the homogeneity in a substrate, and stability as compared with the approach of (1), since the heat-treatment covering the long time of about 30 hours is needed with a high temperature service 600 degrees C or more, the processing time becomes long and it has the problem that a throughput cannot be raised. Furthermore, in the approach of (2), since the crystal structure crystallized turns into twin crystal structure, about several micrometers comparatively big crystal grain is obtained, but since many twin crystal defects are included in crystal grain, the crystallinity has the problem of being inferior to the crystallinity of the silicon semi-conductor film manufactured by the approach of the above (1).
[0007] On the other hand, the above (1) and the approach of (2) are improved, respectively, and the method of

obtaining the high-definition crystalline silicon film is developed.
[0008] First, pulse laser light is irradiated as the improvement approach of the approach of (1) to the exposure field formed with the mask. Fuse the silicon film of the exposure field where this pulse laser light was irradiated, and the silicon film by which melting was carried out by carrying out sequential solidification from the field close to a surrounding non-irradiating field (unmelting field) The crystallization art which controlled the direction of crystal growth is indicated by the ** table No. 505241 [ 2000 to ] official report using the phenomenon in which crystallization progresses with directivity.
[0009] By making small the scanning pitch of a pulse laser irradiated while scanning to the amorphous silicon film, it is controlling by this crystallization art so that a crystal grows in the direction along a scanning direction. Furthermore, the crystalline region near the single crystal which does not have the grain boundary with small area comparatively is manufactured by adjusting the configuration of a mask, and the island configuration of the silicon film where laser is irradiated.
[0010] Moreover, the approach of aiming at fall of whenever [ stoving temperature ], compaction of the processing time, and crystalline improvement attracts attention by introducing the catalyst element which promotes crystallization of the amorphous silicon film as the improvement approach of the approach of (2).
[0011] It considers as the crystalline silicon film by specifically heat-treating, after introducing metallic elements, such as nickel of a minute amount, into the front face of the amorphous silicon film.
[0012] By the approach using such a catalyst element, the crystalline nucleus which used as the nucleus the metallic element introduced into the amorphous silicon film occurs at an early stage, and crystallization advances rapidly focusing on this crystalline nucleus after that.
[0013] According to early generating of the crystalline nucleus by installation of a catalyst element, while this approach can aim at fall of whenever [ stoving temperature ], and compaction of the processing time The crystalline silicon film the crystalline silicon film which carried out crystal growth grew up to be with the usual solid phase grown method (the approach of the above (2)) Unlike the case where it has the twin crystal structure where a crystal defect increases, it has the structure where two or more columnar crystals (network) stand in a row, and each columnar crystal is in the condition with the interior near a single crystal, though it is small.
[0014] The crystal growth approach of growing up a crystal into the boundary region in a longitudinal direction from the introductory field where the catalyst element was introduced is indicated by JP,11-2607823,A by heat-treating by introducing a catalyst element into some fields of the amorphous silicon film.
[0015] By the crystal growth approach indicated by especially this official report, stabilization of lateral crystal growth is attained by making into the shape of a stripe (Rhine - and - tooth space) the introductory pattern of the field where a catalyst element is introduced, and specifying the width of face of that introductory pattern, and spacing between each introductory pattern.
[0016] Moreover, in order to raise further the crystallinity of the crystalline silicon film which carried out solid phase crystallization by introducing and heat-treating a catalyst element as the crystal growth approach which combined the approach of the above (1), and the approach of the above (2), the crystal growth approach of adding further the process which irradiates strong light, such as laser light, after heat-treatment is indicated by JP,7-161634,A. By carrying out by adding such an optical exposure process, the crystallinity of the crystalline silicon film crystallized by heat-treating under catalyst element existence is raised further, and further improvement in the speed of a semiconductor device is attained.
[0017]
[Problem(s) to be Solved by the Invention] The silicon film of the field fused by the exposure of laser light is carried out under ** one by one from the field close to a surrounding non-irradiating field (unmelting field), and since the directivity is controlled and crystallized, the crystalline silicon film obtained in the above-mentioned ** table No. 505241 [ 2000 to ] official report is constituted by the crystal grain (grain) of the shape of a column by which the growth direction was controlled. Drawing 11 is the sectional view showing the condition of this crystal grain roughly. Here, X01 shows the direction of crystal growth, and X02 shows the grain boundary.
[0018] However, the crystal grain which grows by this approach is irrelevant between each crystal grain and about both field bearing of a crystal, although two or more columnar crystals to which it grew up in the same direction mostly, and the growth direction was equal are formed as shown in drawing 11 . Therefore, the crystal defect and the azygos joint hand are in the condition of having generated in high frequency at each grain boundary section, and the trap obstruction over migration of the carrier of a semiconductor device becomes large. Consequently, by the case where the migration direction and the direction of crystal growth of a carrier are parallel to the active region of a semiconductor device, and the case where it is not parallel, if the number of the grain boundaries which will differ and a carrier crosses with the large number of the grain boundaries which a carrier crosses becomes large, that property will fall remarkably and dispersion in the property between components will become large.
[0019] When TFT is produced so that the migration direction of a carrier may specifically become in parallel or

perpendicular to the crystal growth direction by using the above-mentioned approach, the difference in an about 5-time big property arises [ the migration direction of a carrier ] between parallel or TFT which became perpendicular, and the constraint by which it is given to a component design layout becomes large.

[0020] Moreover, as the growth direction meets in the migration direction of the carrier of a semiconductor device, even if it is the case where a semiconductor device is produced, as shown in drawing 11 , a limitation is in the die length of the crystal grain which meets in the direction of crystal growth, and it will be in the condition that two or more crystal grain was connected within the semiconductor device. For this reason, the property of a semiconductor device is influenced by the condition that the crystallized state in the active region of each semiconductor device and its columnar crystal were connected, and there is a possibility that big dispersion may arise.

[0021] Drawing 12 is the top view showing the result of having crystallized the silicon film as a configuration which includes a crookedness configuration for the mask for forming the exposure field where a laser beam is irradiated in the crystallization art indicated by the ** table No. 505241 [ 2000 to ] official report. X01 shows the direction of crystal growth, and X02 shows the grain boundary.

[0022] Thus, by including a crookedness configuration in mask shape, the field near a single crystal can be formed in a part like the field which also shows the crystallization art indicated by the ** table No. 505241 [ 2000 to ] official report by X03 surrounded by the grain boundary. However, this field cannot be greatly grown up into the forge fire which forms the active region of a semiconductor device only by this field. Moreover, it is necessary to carry out alignment (alignment) of the active region of a semiconductor device with high precision to this single crystal field X03, and there is also a problem that a process becomes complicated.

[0023] Moreover, if the crystalline silicon film obtained by the approach of JP,11-260723,A is seen in macro as shown in drawing 13 , the crystal growth condition is uniform and the comparatively big field has had complete set of crystal-face bearing uniformly. Here, in Y01, the direction of crystal growth and Y02 show the grain boundary, and Y03 shows the introductory field of a catalyst element, respectively.

[0024] As compared with the grain boundary shown in drawing 10 , the grain boundary of the crystalline silicon semi-conductor film obtained by this approach is large, and can also form the active region of a semiconductor device in one crystal grain so that it may be shown by the field surrounded by Y02 of drawing 12 .

[0025] However, by the crystalline silicon film obtained by this approach, there is a problem that the crystal defect which appears in crystal grain increases. The crystalline silicon film crystallized by introducing and heating a catalyst element constitutes crystal grain, where the network which the columnar crystal with a width of face of 800-1000A connected mutually is formed. Although the interior of each columnar crystal is in the single crystal condition, many crystal defects, such as transition, will arise in crystal grain by the deflection of each columnar crystal, branching, etc. Therefore, by the crystalline silicon semi-conductor film obtained by this approach, even if it forms the active region of a semiconductor device by one field with single field bearing, engine performance sufficient for the crystal defect which exists in crystal grain cannot be obtained. For example, it becomes at most 100cm2/Vs extent with the electric field effect mobility of TFT.

[0026] Moreover, even if it is very difficult to form the active region of a semiconductor device according to one field which had single field bearing in practice and unites the direction of crystal growth in the carrier migration direction, the grain boundary Y02 will surely be included in an active region. For this reason, dispersion in the property of a semiconductor device cannot be reduced with the crystalline silicon semi-conductor obtained by this approach.

[0027] By the approach indicated by JP,7-161634,A, in order to extinguish a lot of crystal defects in the crystal grain which appears in the crystalline silicon film crystallized with the catalyst element, the process which irradiates strong light, such as laser light, is added further. However, if the laser power of laser light is too high, since the effectiveness which will irradiate laser light if the laser power of laser light is too low does not appear, but it will be in the condition of maintaining the original crystallized state mostly, and it will be in the same crystallized state as the case where the original crystallized state was reset and only laser light crystallizes, it is not easy to irradiate strong light, such as laser light, proper, and there is almost no margin of laser power.

[0028] Moreover, when the laser power of the laser light irradiated is the optimal, while the crystal defect in crystal grain can be reduced maintaining the crystallinity in the crystallization process by the catalyst element, the grain boundary by the recrystallization process by laser light will newly be generated. As compared with the grain boundary seen where solid phase crystallization is carried out with a catalyst element, the new grain boundary generated by such laser light exposure has a large trap consistency to a semi-conductor carrier, and the energy is also high.

[0029] in the semiconductor device using the crystalline silicon semi-conductor film obtained by this approach, compared with the approach of crystallizing according the amorphous silicon film of the former [ recrystallize / the high homogeneity of the crystalline silicon film which carried out solid phase crystallization with the catalyst element / inherit and ] to direct laser, the homogeneity of a crystal is boiled markedly and becomes high. Moreover, since there is less effect than the grain boundary which it produced when the new grain boundary produced by the exposure of laser light carried out solid phase crystal growth by installation of a catalyst element, improvement in the property of a

semiconductor device can be aimed at in total by adding a laser light exposure process.
[0030] However, since generating of the new grain boundary accompanying a laser light exposure takes place at random, dispersion produces it in the property of a semiconductor device under the effect. Consequently, compared with the semiconductor device produced only by solid phase crystallization by the catalyst element, a property becomes unstable, and dispersion on a property becomes large, and by the crystalline silicon semi-conductor film obtained by this approach, in order to realize the semiconductor device of the high-speed engine performance which has high-speed current drive ability, it has come to acquire sufficient property.
[0031] This invention aims at offering the semiconductor device with which it is made in order to solve the above-mentioned technical problem, and it has the high-speed engine performance which has high-speed current drive ability, and dispersion in the engine performance was reduced, and its manufacture approach.
[0032]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the semiconductor device of this invention It is the semiconductor device by which the active region was formed with the silicon film which has crystallinity on the substrate which has an insulating front face. This active region The field by which solid phase growth was carried out along the one direction is used as seed crystal from the field where the catalyst element of the minute amount which promotes crystallization of the amorphous silicon film was introduced. It is characterized by being formed in an outline one direction with the silicon film which has the crystallinity by which crystal growth was carried out by carrying out melting solidification of this field by which solid phase growth was carried out.
[0033] In the semiconductor device of above-mentioned this invention, it is desirable by [ said ] carrying out melting solidification that the crystal growth direction of the silicon film which has the crystallinity by which crystal growth was carried out is a direction which carries out an outline rectangular cross to the crystal growth direction of said field by which solid phase growth was carried out.
[0034] In the semiconductor device of above-mentioned this invention, said active region is formed of the crystal grain group of the shape of Rhine located in a line with the outline one direction along the crystal growth direction of the field by which crystal growth was carried out by [ said ] carrying out melting solidification, and, as for the crystal grain group of the shape of this Rhine, it is desirable to have the almost same field bearing as the crystal grain group of the adjoining shape of other Rhine.
[0035] In the semiconductor device of above-mentioned this invention, it is desirable that the gap of field bearing of each shape of said Rhine crystal grain between groups is less than 5 degrees.
[0036] In the semiconductor device of above-mentioned this invention, said active region is formed of the crystal grain group of the shape of Rhine located in a line with the outline one direction along the crystal growth direction of the field by which crystal growth was carried out by [ said ] carrying out melting solidification, and, as for the grain boundary of the crystal grain group of this shape of each Rhine, it is desirable that at least 80% or more of silicon atom is connected in the shape of a grid on atomic level.
[0037] As for said active region, in the semiconductor device of above-mentioned this invention, it is desirable by [ said ] carrying out melting solidification that it is formed of the crystal grain group of the shape of Rhine located in a line with the outline one direction along the crystal growth direction of the field by which crystal growth was carried out, and the small angle tilt boundary is formed between the grain boundaries of this shape of each Rhine.
[0038] As for said small angle tilt boundary, in the semiconductor device of above-mentioned this invention, it is desirable that the angle of rotation of superficial bearing between each crystal grain is less than 5 degrees.
[0039] the semiconductor device of above-mentioned this invention -- setting -- said grain boundary -- SEKOETCHINGU -- it is desirable that the location is specified by etching by law.
[0040] the semiconductor device of above-mentioned this invention -- setting -- the inclination of field bearing of said crystal grain group, and the crystal orientation in the grain boundary -- EBSP -- it is desirable that it is the field measured by law.
[0041] As for said active region, in the semiconductor device of above-mentioned this invention; it is desirable to be formed so that it may become outline parallel to the direction along the crystal growth direction of the field by which crystal growth was carried out, and the grain boundary of each shape of said Rhine by carrying out melting solidification of the migration direction of the carrier which moves in said active region.
[0042] As for the active region formed in said active region, in the semiconductor device of above-mentioned this invention, it is desirable to contain the nickel element which is a catalyst element by the concentration of 1x1016 - 5x1017 atoms/cm3.
[0043] Moreover, the process which introduces alternatively the catalyst element which promotes crystallization of the amorphous silicon film into some amorphous silicon film with which the manufacture approach of the semiconductor device of this invention was formed on the substrate which has an insulating front face, The process which this catalyst element makes carry out sequential crystallization from the contiguity part of the field introduced alternatively, and uses as the crystalline silicon film by heat-treating this amorphous silicon film, It is characterized by including the

process which heats and carries out sequential recrystallization of it, scanning this crystalline silicon film in the predetermined direction, and the process which forms an active region with the crystalline silicon film which it this recrystallized.
[0044] As for the crystalline silicon film crystallized by installation of said catalyst element, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to be heated by scanning laser light along the direction which intersects perpendicularly with this crystallization direction.
[0045] In the manufacture approach of the semiconductor device of above-mentioned this invention, said catalyst element is introduced into the field formed the shape of Rhine, and in the shape of a stripe on the amorphous silicon film formed on the substrate which has said insulating front face, and, as for said laser light, it is desirable to be scanned along the direction where the field formed this shape of Rhine and in the shape of a stripe extends.
[0046] As for each width of face of the field formed said shape of Rhine, and in the shape of a stripe, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to be formed in the range of 1-15 micrometers.
[0047] As for the process which heats and carries out sequential recrystallization of it in the manufacture approach of the semiconductor device of above-mentioned this invention, scanning the crystalline silicon film crystallized by installation of said catalyst element in the predetermined direction, it is desirable by scanning a substrate or pulse laser light to an one direction to be carried out by carrying out sequential recrystallization reflecting the crystallinity of the field which the pulse laser light of the preceding paragraph recrystallized, irradiating pulse laser light at this crystalline silicon film.
[0048] Among said pulse laser light irradiated in the manufacture approach of the semiconductor device of above-mentioned this invention while being scanned by said crystalline silicon film in the fixed direction, at least the pulse laser light of the 1st step As for the pulse laser light of the 2nd step after the field crystallized by installation of said catalyst element irradiated and the exposure of the pulse laser light to this field was performed, it is desirable that the field to which crystal growth by installation of a catalyst element is not performed irradiates.
[0049] As for the scanning pitch of said pulse laser light, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to be set below to the die length which the field of the crystalline silicon film fused at the time of the exposure of said pulse laser light can recrystallize reflecting the crystallinity of the crystalline silicon film of an adjoining unmelting field.
[0050] As for the scanning pitch of said pulse laser light, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable that it is 0.1 micrometers - 1.5 micrometers.
[0051] As for said pulse laser light, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable that it is long along a perpendicular direction to the direction scanned.
[0052] In the manufacture approach of the semiconductor device of above-mentioned this invention, the profile of the beam reinforcement of said pulse laser light on the strength has the desirable thing of said pulse laser light which the profile of the opposite side of a scanning direction on the strength falls from fixed reinforcement up to 0 reinforcement rapidly at least.
[0053] As for the scanning direction, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is [ said pulse laser light ] desirable to irradiate using a laser radiation means to have the electric shielding means which carries out the mask of a part of opposite side mechanically.
[0054] As for the electric shielding means of said laser radiation means, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to cover the range to which reinforcement falls the pulse laser light irradiated continuously from reinforcement required for melting of said crystalline silicon film at least.
[0055] As for said pulse laser light, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to irradiate by the reinforcement which said crystalline silicon film fuses over the whole film.
[0056] As for said pulse laser light, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to irradiate in the range in which an excimer laser with a wavelength of 400nm or less is used, and the energy density to the front face of said crystalline silicon film serves as 200 - 600 mJ/cm2.
[0057] As for the process which heats and carries out sequential recrystallization of it in the manufacture approach of the semiconductor device of above-mentioned this invention, scanning the crystalline silicon film crystallized by installation of said catalyst element in the predetermined direction, it is desirable by scanning a substrate or continuous-wave-laser light to an one direction to be carried out by carrying out sequential recrystallization reflecting the crystallinity of the field which continuous-wave-laser light recrystallized previously, irradiating continuous-wave-laser light at this crystal silicon film.
[0058] As for the process which irradiates continuous-wave-laser light at said crystalline silicon film, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable that sequential recrystallization is performed, melting of the silicon film of an exposure field being carried out by this continuous-

wave-laser light, and moving the interface of the solid state in the silicon film, and a liquid condition with the scan of this continuous-wave-laser light.
[0059] In the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable as said continuous-wave-laser light that solid state laser is used.
[0060] As for said active region, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable to be formed along the scanning direction of said laser light.
[0061] As for the catalyst element which promotes crystallization of said amorphous silicon film, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable that it is at least one element chosen from nickel, Co, Fe, Pd, Pt, Cu, and Au.
[0062] After performing the process which carries out sequential recrystallization of said crystalline silicon film by scanning said laser light in the manufacture approach of the semiconductor device of above-mentioned this invention At least the process which introduces the element chosen as the field of the crystalline silicon film except becoming an active region according to a next process from five groups B, and by performing 2nd heat-treatment to this crystalline silicon film It is desirable to perform further the process which reduces the amount of said catalyst element contained to the field of the crystalline silicon film which is made to move said catalyst element to the field to which the element chosen from said five groups B was introduced, and serves as an active region according to a next process.
[0063] As for the migration direction of said catalyst element moved by said 2nd heat-treatment, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable that they are the scanning direction of said laser light and outline parallel.
[0064] As for the element chosen from said five groups B, in the manufacture approach of the semiconductor device of above-mentioned this invention, it is desirable that it is at least one element chosen from P, N, As, Sb, and Bi.
[0065]
[Embodiment of the Invention] Hereafter, the manufacture approach of the semiconductor device of this invention and the semiconductor device manufactured by this manufacture approach are explained based on a drawing.
[0066] Drawing 1 (a) - (d) is the top view of the semiconductor device which explains the outline in each process of the manufacture approach of the semiconductor device concerning this invention, respectively.
[0067] Drawing 1 (a) shows the condition of having made the one direction carrying out crystal growth of the silicon film to the introductory stripe-like field 1, by introducing and heat-treating a catalyst element to the introductory field 1 of the catalyst element formed in the shape of a stripe. Thus, by forming the introductory field 1 of a catalyst element in the shape of a stripe, it will crystallize in outline primary in the direction of the arrow head A which goes direct in the introductory stripe-like field 1, consequently the silicon film is surrounded by the domain boundary 3 almost parallel to an arrow head A, and the crystal domain 4 which has almost single field bearing is formed. Moreover, it hurts by carrying out the rate of crystallization to the direction of arrow-head A from each catalyst element installation field 1, and in order that each crystal domain 4 which carried out crystal growth from each catalyst element installation field 1 may collide by the interstitial segment of each catalyst element installation field 1, the growth boundary 5 is formed in the abbreviation interstitial segment of each catalyst element installation field 1.
[0068] Next, melting solidification of the field where pulse laser light was irradiated and pulse laser light was irradiated is carried out to the silicon film crystallized by installation of a catalyst element.
[0069] Drawing 1 (b) shows the condition of having irradiated 1 time of pulse laser light along the perpendicular direction to the stripe-like catalyst element installation field 1 on the crystalline silicon film which is in the condition of drawing 1 (a). Thus, by irradiating pulse laser light, the silicon film in the field 6 where pulse laser light was irradiated fuses momentarily, and recrystallizes immediately after that. In this case, crystal growth carries out sequential advance along the direction of an arrow head B reflecting the crystallinity of a non-irradiating field from the both ends close to the non-irradiating field to which the pulse laser light in a field 6 is not irradiated, and the field 8 crystallized in the longitudinal direction along this direction is formed. Moreover, in the central part of a field 6, since the fused silicon film will be in a supercooling condition and a crystalline nucleus occurs at random, in this part, the field 9 to which crystallization without directivity went is formed.
[0070] Next, in the field 6 where the first pulse laser light is irradiated, the pulse laser light of a two-times eye is irradiated along a field 6 so that a part may overlap.
[0071] Drawing 1 (c) shows the condition after irradiating the pulse laser light of a two-times eye. Solidification crystallization of the silicon film which the silicon film of the field 10 where pulse laser light was irradiated fused, and was fused after that by the exposure of this pulse laser light progresses. In this case, crystallization progresses one by one from the edges on both sides of a field 10 like the case of an exposure of the first above-mentioned pulse laser light reflecting the crystallinity of an adjoining non-irradiating field. Therefore, as the field where laser light was irradiated by the two-times eye succeeds the crystal growth of the field 8 crystallized by the exposure of the first pulse laser light, a crystal grows. Consequently, the field 11 by which crystal growth is newly carried out forms the field 12 which was extended from the field 8 crystallized by the exposure of the first pulse laser light and which changed into the single

crystal condition mostly.
[0072] A single crystal condition field can be formed covering a big area shown in the field 14 of drawing 1 (d) by scanning such a pulse laser light sequentially in the direction shown in drawing 1 (d) by the arrow head C. Thus, if the field 14 of a single crystal condition is formed, the field 15 in which the catalyst element installation field 1 was formed, and the growth boundary section 16 will be avoided continuously, and the active region 17 of a semiconductor device will be formed in the field 14 of this single crystal condition.
[0073] Thus, the crystalline silicon film which carried out crystal growth to the longitudinal direction with the catalyst element has the field (domain) of single field bearing in a comparatively big area along the growth direction, its gap of bearing between each domain is mutually small, and the trap level to a carrier is also low. The silicon semi-conductor film which the melting solidification by pulse laser light exposure recrystallized by using as seed crystal the field which has such a description In order to inherit the crystal component nature good in micro and the homogeneity of field bearing of the silicon film by longitudinal direction crystallization by the catalyst element and to grow up, There is almost no crystal defect and field bearing can form the crystalline silicon film in the condition almost near a single crystal of having gathered over the big field, covering the magnitude of several 10 micrometers - 100 micrometers of numbers. Therefore, a semiconductor device with small dispersion in a property can be manufactured highly efficiently by forming the active region of each semiconductor device in the field excellent in such crystallinity. This is effective when especially a high current forms the active region of TFT where required channel width is large.
[0074] Moreover, as the manufacture approach of the semiconductor device of this invention, continuous-wave-laser light besides pulse laser light is also applicable. The crystalline silicon film crystallized with the catalyst element is irradiated, by scanning continuously, reflecting the crystallinity of the crystalline silicon film crystallized with the catalyst element, crystal growth can go to a scanning direction and a crystal grain group can make continuous-wave-laser light almost the same [ a list and field bearing between the contiguity crystal grain ] in an one direction.
[0075] Drawing 14 is the sectional view showing roughly the change of state of the silicon film at the time of irradiating continuous-wave-laser light and the silicon film, and shows the case where it irradiates scanning continuous-wave-laser light in the direction of an arrow head 303 on the crystalline silicon film 302 formed through $SiO_2$ film 301 on the glass substrate 300.
[0076] Thus, when continuous-wave-laser light is used, unlike pulse laser light, the crystalline silicon film serves as an elevated temperature, and the field where laser light is irradiated will always be in a melting condition. Moreover, as for the part after continuous-wave-laser light was irradiated, recrystallization after melting is performed. Therefore, on the silicon film 302 with which continuous-wave-laser light was irradiated, liquefied field 302a for which laser light was irradiated and which changed into the liquefied condition, and individual field 302b of the solid state which it recrystallized after laser light was irradiated exist.
[0077] If continuous-wave-laser light is scanned in the direction of the arrow head 305 shown in drawing 14 , the interface part of this solid-state field 302b and liquefied field 302a which are shown by 304 in drawing will move in the direction shown by the arrow head 306 along the scanning direction of continuous-wave-laser light, and recrystallization of the crystalline silicon film will progress one by one along this arrow-head 305 direction.
[0078] When continuous-wave-laser light is used, unlike the case where pulse laser light is used in this way, it is in the condition which the interface of a solid-state part and a liquefied part produced on the silicon film, and crystallinity is always controlled by the continuous-wave-laser luminous intensity and the scan speed which are irradiated by the silicon film. Therefore, when the scan speed of continuous-wave-laser light is too slow, the crystalline silicon film will be heated beyond the need and the crystalline information on the silicon film of the origin crystallized by the catalysis of a catalyst element will be reset. Moreover, also when continuous-wave-laser luminous intensity is too strong, the same problem arises. For this reason, in using continuous-wave-laser light, the optimum value of laser luminous intensity and a scan speed exists.
[0079] As such a continuous-wave-laser light, solid state laser is desirable and excellent in stability. Moreover, as wavelength of the laser light irradiated, unlike the case where the above-mentioned pulse laser light is used, if it is 600nm or less, it can fully be used.
[0080] In the manufacture approach of the above-mentioned semiconductor device, the field which carried out crystal growth to the longitudinal direction by installation of a catalyst element The crystal domain which had complete set of field bearing along the growth direction is formed. It is laser light (pulse laser light, continuous-wave-laser light, and the following, only when expressing it as "laser light", pulse laser light and continuous-wave-laser light shall be shown) to a perpendicular direction to the direction to which this crystal growth went. It scans and crystallization by melting solidification is advanced. for this reason, since the crystal growth of it was carried out using one crystal domain as seed crystal, there was almost no crystal defect, and field bearing reached far and wide and it gathered -- it excels in crystallinity very much and the crystallization field almost near a single crystal condition can be obtained. Therefore, as for the direction of the crystal growth by installation of a catalyst element, and the direction of the crystal growth by the melting solidification by laser radiation, it is desirable that it is an outline perpendicular.

[0081] Moreover, the crystal grain which the active region of the semiconductor device manufactured by the above-mentioned approach is constituted by the crystal grain group located in a line in the shape of Rhine along the crystal growth direction in melting solidification crystallization by the exposure of laser light, and was located in a line in the shape of Rhine has the almost same field bearing as each crystal grain of the shape of adjoining Rhine. For this reason, while being able to reduce the effect of the grain boundary, the trap consistency to the semi-conductor carrier in that grain boundary is also reduced, and energy of a trap level can also be made small. Consequently, the semiconductor device which has such an active region should have high performance and high current drive ability very much, and its dispersion between semiconductor devices should be still smaller, and it should be excellent in stability.
[0082] in addition, drawing 1 -- setting -- a grain boundary -- SEKOETCHINGU -- it is shown as a location etched by law, and crystal grain is shown as a field surrounded by the grain boundary. furthermore, the inclination of field bearing between crystal grain, and the crystal orientation in the grain boundary -- EBSP -- the value measured by law is shown.
[0083] Also by the approach of the ** table No. 505241 [ 2000 to ] official report, the crystal grain group of the shape of Rhine located in a line along the same direction can be obtained seemingly. However, since there is no relevance in field bearing between each adjoining crystal grain and each is independent by the semi-conductor film obtained by this approach, the trap consistency of the grain boundary to a carrier becomes very large, and if there is a semiconductor device which a carrier moves over Rhine-like crystal grain, while that property falls remarkably, dispersion between components will become large.
[0084] When there is actually no mutual relevance in field bearing of adjoining Rhine-like crystal grain, an about 5-time big difference produces the difference of the electric field effect mobility in TFT to which the migration direction of a carrier becomes parallel to the direction of Rhine, and TFT which becomes perpendicular. On the other hand, in the semiconductor device of this invention, although a difference is similarly looked at by electric field effect mobility, the difference of electric field effect mobility becomes about 1.5 times, and the difference is reduced rather than above TFT. Moreover, in the semiconductor device of this invention, since whenever [ electric-field migration effectiveness ] improves as compared with the conventional semiconductor device, as compared with the conventional semiconductor device, big constraint is not received in the design layout between components.
[0085] Moreover, in the semiconductor device of this invention manufactured as mentioned above, the gap of field bearing between the crystal grain of the adjoining shape of each Rhine is less than 5 degrees. For this reason, the continuity in the grain boundary section is maintained and the energy of the trap consistency in the grain boundary section to a semi-conductor carrier and a trap level can be reduced to extent to which the property of a semiconductor device is not reduced greatly.
[0086] Moreover, in the semiconductor device of this invention manufactured as mentioned above, the grain boundary of the crystal grain group of the shape of Rhine which constitutes the active region of a semiconductor device is in the condition of having been continuously connected on atomic level. For this reason, the trap consistency and energy level of a carrier in the grain boundary can be made the smallest. In this invention, it turns out further in the grain boundary that 80% or more of silicon atom is continuously connected on atomic level. By this Even if it suppresses dispersion in a property (electric field effect mobility) within **5% and the direction of melting solidification crystallization of the silicon film by the exposure of laser light differs from the 90 degrees of the migration directions of a semi-conductor carrier, it turns out that electric field effect mobility can be held down to the difference of 2 double less or equal.
[0087] Furthermore, it means that the Rhine-like grain boundary where it adjoins that a grid is continuously connected on atomic level between each crystal grain constitutes the small angle tilt boundary. by the small angle tilt boundary, it is in the condition that saw superficially and the gap of crystal orientation has arisen in the minute angle of rotation, and the list of the grid itself rotates at a small include angle in the grain boundary -- **** (refracted) -- the grids of the crystal grain which adjoins in the grain boundary are in the connected condition. If it is in such a condition, while being able to make the smallest the trap consistency and energy level of a carrier in the grain boundary, consequently being able to raise the high-speed property of a semiconductor device to the maximum, dispersion in the property between each component can be made into min. Furthermore, as for the small inclination grain boundary between the crystal grain of the shape of Rhine adjoined at this time, that angle of rotation is less than 5 degrees. For this reason, the energy of the trap consistency in the grain boundary section to a semi-conductor carrier and a trap level can be reduced to extent to which the property of a semiconductor device is not reduced greatly.
[0088] Moreover, in the semiconductor device of this invention, it is desirable to constitute a semiconductor device so that the migration direction of the carrier in an active region and the direction of Rhine of the crystal grain of the shape of Rhine located in a line as outline ******** in the crystalline silicon film which constitutes this active region may serve as outline parallel. Thus, if a semiconductor device is manufactured, the effect of the grain boundary to a carrier can be eliminated as much as possible to the component especially asked for high carrier mobility. However, in the semiconductor device of this invention, if it compares with the conventional semiconductor device even when the direction of Rhine and the migration direction of a carrier do not become parallel as mentioned above, very high mobility will be obtained. Therefore, the semiconductor device of this invention can enlarge the degree of freedom of a

design layout.
[0089] Moreover, the semiconductor device of this invention has introduced into the amorphous silicon film the catalyst element which promotes crystallization, in order to control field bearing of the crystal grain of the shape of adjoining Rhine. Even if it can use a kind or two or more sorts in nickel, Co, Fe, Pd, Pt, Cu, Au, etc. and uses any as a catalyst element which promotes such crystallization, crystallization of the amorphous silicon film can be promoted by the minute amount.
[0090] However, as for a catalyst element, it is desirable that the lattice constant in the silicide compound of a catalyst element resembles the lattice constant of single crystal silicon in order to promote crystal growth by silicide-izing in the amorphous silicon film. nickel forms Si of two atoms, and NiSi2 which is a silicide compound. NiSi2 has the crystal structure of a fluorite mold, and the crystal structure is very similar with the diamond structure of single crystal silicon. And to the crystal silicon of the diamond structure which has the lattice constant of 5.430A, the lattice constant is 5.406A and NiSi2 is the closest to the lattice constant of silicon. Therefore, since it becomes the most excellent mold on the occasion of crystallization of the amorphous silicon film and crystallization of the amorphous silicon film is promoted most, nickel is suitable for NiSi2 as a catalyst element.
[0091] Since the process which carries out solid phase crystallization of the amorphous silicon film in a longitudinal direction with a catalyst element is first performed in case the semiconductor device of this invention is manufactured, a catalyst element will be contained in the activity (channel) field in the active region of a semiconductor device. If the concentration of the nickel contained in the active region of a semiconductor device exceeds 5x1017 atom/cm3, the field which exists all over an active region as nickel silicide will increase, and it will have a bad influence on the property of a semiconductor device. Moreover, if the concentration of nickel becomes less than 1x1016 atom/cm3, it cannot fully acquire the catalyst effectiveness by installation of nickel, and cannot fully control to field bearing of crystal grain. Therefore, as for nickel, it is desirable to introduce so that it may become the concentration of 1x1016 - 5x1017 atom/cm3.
[0092] Moreover, the width of face of the catalyst element installation field for introducing the catalyst element formed the shape of Rhine, and in the shape of a stripe When introducing the catalyst element of concentration required for lateral crystal growth in not fulfilling 1 micrometer exceeds 15 micrometers conversely rather than it is easy The introduced catalyst element does not act on lateral crystal growth efficiently, but what remains to an introductory field occurs, and various problems, such as effect on the autodoping in the laser scan of the back from a high concentration field, the etching damage to the substrate film, and a TFT property, arise. Therefore, as for the width of face of a catalyst element installation field, it is desirable to set it as 1-15 micrometers.
[0093] When manufacturing the semiconductor device of this invention, although the 1st-step pulse laser light exposure is irradiated to the crystalline silicon film made [ the longitudinal direction ] to carry out crystal growth with a catalyst element, the field which turns into an active region of a semiconductor device behind has at least an approach effective [ the exposure ] which forms laser light using the field crystallized by irradiating from the crystallization field by the catalyst element.
[0094] A catalyst element is a metallic element which is mainly concerned with transition metals, such as nickel, that such a catalyst element exists in the semi-conductor film checks the dependability and electric stability of a semiconductor device, and it is not a desirable thing. If these catalyst elements exist as silicide especially, in TFT, the big problem of the leakage current increase at the time of off actuation will be caused. Only when growing up the crystal which turns into seed crystal by manufacturing a semiconductor device by the above approaches, a catalyst element is used efficiently. So, in the active region of an actual semiconductor device If the field (field which grew by pulse laser light reflecting the crystallinity of seed crystal) which does not correspond to the crystallization field by the catalyst element is used, the amount of the catalyst element which remains to the active region of a semiconductor device can be reduced as much as possible, and the dependability of a semiconductor device can be raised.
[0095] Moreover, when manufacturing the semiconductor device of this invention, irradiating laser light in pulse or continuously by introducing a catalyst element alternatively at the crystalline silicon film made [ the longitudinal direction ] to carry out solid phase growth By making an one direction scan laser light to a substrate, by carrying out sequential recrystallization reflecting the crystallinity of the field crystallized by the pulse irradiation of the preceding paragraph, the highly efficient semiconductor device is manufactured and this process serves as most important process. When having become more than the die length which can recrystallize the scanning pitch of pulse laser light especially reflecting the crystallinity of the unmelting field where the field fused in case pulse laser light is irradiated adjoins Since the field by the random crystalline nucleus seen by the usual laser light exposure is formed and the crystal grain of the shape of a usual grain is formed, the scanning pitch of pulse laser light It is necessary to carry out to below the die length that can recrystallize reflecting the crystallinity of the unmelting field where the field where the field fused in case pulse laser light is irradiated adjoins adjoins. By making it such die length, crystal grain is formed in the shape of Rhine along the growth direction.
[0096] Drawing 2 is the schematic diagram showing the laser annealer used for the melting solidification process of the

silicon film by the exposure of laser light, when manufacturing the semiconductor device of this invention.
[0097] This laser annealer has the laser oscillation machine 21 which oscillates the laser light D of predetermined reinforcement. It is reflected by the mirror 22 and the laser light D oscillated by the side from this laser oscillation machine 21 is led to the homogenizer 23 installed above the substrate. And the laser light E of a long configuration which met the one direction with this homogenizer 23 is formed. Between this homogenizer 23 and substrate, the electric shielding mask 24 which makes laser light E of a long configuration a desired profile on the strength is formed. This electric shielding mask 24 has opening 24a which makes only the part near [ in the profile of the laser light E on the strength ] the top penetrate, and the laser light F which penetrates opening 24a of the electric shielding mask 24 is irradiated on a substrate.
[0098] Since it is what carries out sequential recrystallization of the silicon film reflecting the crystallinity of the field which the pulse irradiation of the preceding paragraph recrystallized when recrystallizing by pulse laser light in this invention, If the laser luminous-intensity profile is the profile which is falling gently-sloping like a general Gaussian configuration Since it will be in the condition that laser energy goes up gradually from the field crystallized from the pulse laser exposure of the preceding paragraph, the energy for which recrystallization is asked is not obtained near the crystal of the field crystallized by the pulse of the preceding paragraph. Therefore, in such a profile on the strength, since a low power field surely exists rather than recrystallization is asked, the crystallinity of the field crystallized by the pulse irradiation of the preceding paragraph cannot be inherited, it cannot remain as a bad crystalline field, and sufficient property cannot be acquired. For this reason, as for the beam reinforcement of the pulse laser light which irradiates on the crystalline silicon film, it is desirable that it is the short rectangle-configuration to which the file of the opposite side on the strength falls rapidly from fixed reinforcement to 0 at least to the direction where pulse laser light is scanned.
[0099] In order to realize the beam profile of such a pulse laser light on the strength, a mask etc. makes a part of opposite side mechanical with the electric shielding mask 24 at least, and he is trying for the pulse laser luminous-intensity file of the opposite side to fall rapidly from fixed reinforcement to 0 to the scanning direction of pulse laser light in the above-mentioned laser annealer. For this reason, a desired profile on the strength can be realized simple, without changing the optical system of laser annealer sharply. Moreover, it becomes easy with the above-mentioned electric shielding mask to adjust the exposure field of pulse laser light.
[0100] Drawing 3 is the explanatory view showing the profile of the pulse laser light E irradiated from a homogenizer 24 on the strength, and the profile of the pulse laser light F which opening 24a of the electric shielding mask 24 is penetrated, and is irradiated on a substrate on the strength.
[0101] Although the profile 31 on the strength serves as a Gaussian configuration as the pulse laser light E fabricated by the long configuration with the homogenizer 24 is shown in drawing 3 The pulse laser light F which penetrated the electric shielding mask 24 Only the high part of the energy near [ the ] the top penetrates opening 24a with the electric shielding mask 24. The part of the skirt where energy is low is cut with the electric shielding mask 24, and reinforcement serves as the Top Hat-like profile 32 on the strength which starts at the top from 0 rapidly. In addition, the electric shielding mask 24 may be installed in other locations, may change the configuration and may be used. Although the amount of [ of a profile on the strength ] both ends are the profiles used as rapid inclination on the strength in drawing 3 , the opposite side should just serve as a profile on the strength which starts rapidly to the scanning direction.
[0102] If the scanning pitch of the pulse laser light at the time of irradiating pulse laser light is 1.5 micrometers or less, it turns out that it can recrystallize reflecting the crystallinity of an adjoining unmelting field. Moreover, if the exposure width of face of pulse laser light is 0.1 micrometers or more, a big limit will not be imposed on laser radiation conditions. Therefore, as for the scanning pitch of pulse laser light, it is desirable that it is the range of 0.1-1.5 micrometers. However, when the throughput (throughput per time amount) in the process which irradiates pulse laser light is taken into consideration, it is so desirable that it sets up within the limits of the above greatly.
[0103] moreover, as the shape of beam irradiated by the crystalline silicon film front face of the pulse laser light in this case If it is enough for it if it has the die length more than a scanning pitch in the scan method, and perpendicular long lay length is taken to a scanning direction, since it can crystallize over a wide range field by the scan of a one-time pulse laser light, As shown in drawing 1 (b) and (c), it is desirable to be formed in the perpendicular direction to the scanning direction of pulse laser light at a long outline long picture rectangle configuration. If it does in this way, since the total power of the laser light for irradiating a pulse laser can be reduced and the exposure of a one-time pulse laser can perform wide range crystallization, the processing time in this process can be shortened sharply.
[0104] If small, melting of the silicon film will not fully be carried out, and pulse laser luminous intensity cannot fully improve the crystal defect which exists after solid phase crystallization by the catalyst element. In this invention, since the silicon film is crystallized reflecting the crystallized state of an adjoining unmelting field, it is necessary to irradiate by making it range on the strength which is fused over the whole field of the crystalline silicon film with which pulse laser light was irradiated at least. Specifically, excimer laser light with a wavelength of 400nm or less is most suitable.

If the excimer laser which irradiates a pulse laser with a wavelength [ such ] of 400nm or less is used, the absorption coefficient to the silicon film can be very high, and a thermal damage cannot be given to a glass substrate, and only the silicon film can be heated in an instant. Moreover, excimer laser light has a large oscillation output, and is suitable for processing a large area substrate. Among such excimer lasers, especially XeCl excimer laser light with a wavelength of 308nm is the most desirable, when attaining fertilization of the crystalline silicon film, since beam size at the time of the optical exposure to a substrate could be enlarged, and it was easy to respond to a large area substrate, since the output was large, and the output is comparatively stable further.

[0105] Furthermore, if the surface energy consistency of laser light becomes small from 200 mJ/cm3 to a silicon film front face when using this laser light, melting of the crystalline silicon film is not fully carried out over the whole film, and the crystal defect which exists after the solidification crystal by the catalyst element cannot fully be improved. Moreover, when 600 mJ/cm3 is exceeded, the ablation (evaporation) of the silicon film arises and there is a possibility that a film jump of the silicon film may occur. For this reason, as for the surface energy consistency of the laser light to a silicon film front face, it is desirable to irradiate pulse laser light, as it becomes 200 - 600 mJ/cm3.

[0106] Drawing 4 is the schematic diagram showing other laser annealer which irradiates laser light to a substrate. In this laser annealer, when forming the electric shielding mask 41 in which opening 41a of the shape of two or more Rhine was formed, between a substrate 101 and a homogenizer (not shown in drawing 4 ) and irradiating pulse laser light, two or more fields are crystallized to coincidence at the time of one exposure of pulse laser light. If two or more opening 41a is formed in such an electric shielding mask 41, the pulse laser light G irradiated from a homogenizer 41 will be fabricated by the pulse laser light H of two or more long configurations through the electric shielding mask 41, and the pulse laser light I will be irradiated by two or more places of a substrate.

[0107] If the direction (the direction of a channel) where the carrier of a semiconductor device flows, and the scanning direction of laser light manufacture a semiconductor device as they become outline parallel, since the migration direction of the carrier in the active region of a semiconductor device and the direction of Rhine of the crystal grain of the shape of Rhine of the crystalline silicon film used as an active region will become outline parallel, the effect of the grain boundary to a carrier can be eliminated as much as possible. Therefore, if the active region used for a semiconductor device in this way is designed, the semiconductor device excellent in current drive capacity will be obtained.

[0108] Moreover, when manufacturing the semiconductor device of this invention, the process which introduces a catalyst element and crystallizes the amorphous silicon film in a longitudinal direction is included. It is not desirable that the catalyst element which promotes crystallization mainly got down from metals as mentioned above, and such an element remains so much in a semi-conductor, in order to check the dependability and electric stability of equipment which used the semiconductor device. Then, after using a catalyst element for crystallization of the amorphous silicon film, reduction of the catalyst element which remains is achieved by moving most catalyst elements which remain in this silicon film to fields other than a semiconductor device field. Specifically, the method of performing the process which introduces and heat-treats the element chosen as the field of silicon film other than the activity (channel) field of a semiconductor device and the becoming field from five groups B behind is effective at least. Thereby, the catalyst element which promoted crystal growth can be moved to the field to which the element chosen from five groups B was introduced, and can reduce sharply the amount of survival of the catalyst element in the activity (channel) field of a semiconductor device as a result. This approach is especially effective in the catalyst element of the silicide condition which does a bad influence to a semi-conductor property. And if the field where the 5 group B element was introduced and the catalyst element was introduced is removed and a final semiconductor device field is formed, the high concentration field of a catalyst element will not remain on a substrate.

[0109] In this case, the scanning direction of laser light is met in the semiconductor device of this invention. Since the migration effectiveness of a catalyst element becomes [ the way which moves a catalyst element into the same crystal grain ] good rather than moving a catalyst element over crystal grain which the crystal grain of the shape of Rhine located in a line along the outline one direction is formed, and is different, As for the migration direction which moves a catalyst element to the field to which the element chosen from five groups B was introduced in order to move a catalyst element along the direction of the crystal grain of the shape of Rhine located in a line along the scanning direction of laser light, it is desirable to make it become a scanning direction at the time of irradiating laser light and outline parallel. If it does in this way, the amount of residuals of the catalyst element in the activity (channel) field of a semiconductor device can be reduced greatly as a result.

[0110] Here, as an element chosen from five groups B, a kind of element of P, N, As, Sb, and Bi can be used at least. If a kind or two or more sorts of elements chosen from these are used, the catalyst element contained in the semi-conductor film can be moved efficiently. Although still detailed knowledge is not acquired about the mechanism at the time of moving such a catalyst element, it turns out that the effectiveness of P is the highest also in the above-mentioned element.

[0111] Drawing 15 is a photograph substitution photograph in which the fine structure of the semiconductor device of

above-mentioned this invention is shown, and the arrow head 400 shows the scanning direction of laser light. Thus, in the semiconductor device of this invention, crystal grain 401 is long to the scanning direction of laser light, and has become Rhine-like, and the grain boundary 402 formed in the meantime is formed along the laser scanning direction. The grain boundary 402 between this crystal grain 401 is a grain boundary actualized by SEKOETCHINGU, and in spite of seeing a grain boundary 402, its field bearing between the adjoining crystal grain 401 is almost the same.
[0112] Hereafter, the concrete example using the manufacture approach of the semiconductor device of this invention is explained.
[0113] (Example 1) This example 1 explains the process which manufactures the circuit which has the CMOS structure which is used for the circumference drive circuit of the liquid crystal display of a active-matrix mold, a common thin film integrated circuit, etc., and which constituted the N channel mold TFT and the P channel mold TFT complementary on a glass substrate.
[0114] Drawing 5 (a) - (d) is the top view of the semiconductor device which explains the process which manufactures the CMOS structure which constituted N type TFT and P type TFT of this example 1 complementary, respectively for every process.
[0115] Drawing 6 (a) - (c) explains the process which manufactures the structure of drawing 5 (a) for every process, respectively, and shows the sectional view which meets the A-A' line of drawing 5 (a). Drawing 7 (a) - (g) explains the process which manufactures the structure shown in drawing 5 (b) - (d), respectively for every process of the, and shows the sectional view which meets the B-B' line of drawing 5 (b) - (d).
[0116] In order to prevent first that an impurity is spread from a glass substrate according to a next process as shown in drawing 6 (a) in manufacturing the CMOS structure of this example 1, the substrate film 102 which consists of silicon oxide which has about 300-500nm thickness by the sputtering method or the plasma-CVD method is formed on a glass substrate 101. Next, the intrinsic (I-beam) amorphous silicon film (a-Si film) 103 is formed using a plasma-CVD method in 20-80nm in thickness, and thickness of 50nm. In this example 1, SiH4 gas and H2 gas were used as ingredient gas using the plasma-CVD equipment of an parallel monotonous type. And the plasma was generated for the power density of RF power as 10 - 200 mW/cm22, for example, 80 mW-cm. As for whenever [ stoving temperature / of the substrate at this time ], it was desirable that it is 400 degrees C or less, and it made it 300 degrees C by this example.
[0117] Subsequently, after depositing insulating thin films, such as silicon oxide film or silicon nitride film, over the whole surface on the a-Si film 103, a mask 104 is formed by carrying out patterning. In this example, the silicon oxide film was deposited by using TEOS (Tetra Ethoxy Ortho Silicate) as a raw material on the a-Si film 103 by decomposing and depositing by RF plasma-CVD method under oxygen coexistence. As for the thickness of the silicon oxide film in this case, it was desirable that it is the range of 100-400nm, and it set thickness of the silicon oxide film to 150nm in this example. Of the through hole formed in this mask 104, the field 100 which the a-Si film 103 exposed as shown in drawing 2 (a) is formed in the shape of a slit, and parts other than field 100 are in the condition that it is not exposed of the a-Si film 103 with a mask 104. In this case, as for the Rhine width of face L of each field 100 which the a-Si film 103 has exposed, it was desirable to be set as the range of 1-15 micrometers, and Rhine width of face L of a field 100 was set to 10 micrometers in this example 1.
[0118] Next, the nickel 105 of a minute amount is added on the front face of the a-Si film 103 and a mask 104. Nickel was added by the DC sputtering method, using the target of pure nickel (99.0% or more) as nickel 105 added. It is in the condition to which 2000 mm/min carried out high-speed rotation of the substrate for DC power as about [ 50W ] super-low power, and, specifically, sputtering processing was performed. In this example, sputtering of the nickel under super-low concentration conditions was performed for the gas pressure at the time of sputtering as high-pressure conditions 10Pa or more, using an argon as gas used for this sputtering processing. Although the nickel 105 by which sputtering was carried out is displayed as the shape of a thin film by drawing 6 (a) in order to make a drawing legible, it is formed in monoatomic layer extent or the condition not more than it in fact. The nickel concentration on the 60 a-Si film 103 which has exposed W and argon gas pressure in the field 100 when sputtering is performed as 18Pa conditions actually became about (TRIXRF measured value) two 6x1013 atoms/cm about DC power.
[0119] Next, as shown in drawing 6 (b), nickel anneals whenever [ stoving temperature ] over 11 hours as 530-600 degrees C, for example, 580 degrees C, under an inert gas ambient atmosphere, for example, nitrogen-gas-atmosphere mind, where a spatter is carried out to low concentration.
[0120] Under the present circumstances, in the field 100 in which nickel was added on the front face of the a-Si film 103, silicide-ization of the nickel 105 which exists in a-Si film 103 front face takes place, and field 103a which used silicide as the nucleus and carried out crystal growth is formed in this field 100. And succeedingly, as an arrow head J shows each of drawing 5 (a) and drawing 6 (b) in the boundary region of field 103a, a crystal grows up to be a longitudinal direction (direction parallel to a substrate) from field 103a, and field 103b into which the crystal grew up is formed in a longitudinal direction.
[0121] Thus, crystal grain boundary 103c is formed in the part with which the crystalline silicon film to which the

crystalline silicon film which grew from other field 103a which field 103b of the crystalline silicon film which carried out crystal growth to the longitudinal direction adjoins field 103b Flies, and which it flooded for each other, and crystal growth ended, and carried out crystal growth from both directions collided.

[0122] As shown in drawing 5 (a), domain 103d to which field bearing was equal along the direction of crystal growth, respectively is formed in field 103b which carried out crystal growth to the longitudinal direction. Dotted-line 103e in drawing 5 (a) shows the domain boundary which forms each domain 103d, and the field surrounded by this domain boundary 103e has become one domain. In this case, since the mask of the nickel 105 by which the spatter was carried out on the mask 104 is carried out with a mask 104, the lower layer a-Si film 103 is not reached, but only the nickel 105 added on the a-Si film 103 exposed in the field 100 participates in crystallization of the a-Si film 103. The nickel concentration in the crystalline silicon film which carried out crystal growth to such a longitudinal direction was 5x1017 - about three 1x1018 atom/cm, and the nickel concentration in field 103a in which it was added and direct nickel carried out crystal growth was about three 1x1019 atoms/cm. Moreover, the die length to which crystal growth of the direction parallel to the substrate shown by the arrow head J was carried out on the occasion of the above-mentioned crystal growth was about 130 micrometers in the longest part.

[0123] Next, as shown in drawing 6 (c), etching removal of the mask 104 is carried out. In this example 1, the wet etching using the 1:10 buffered fluoric acid (BHF) which has the selectivity of etching sufficient by the lower layer silicon film 103 as etchant removed the mask 104.

[0124] Next, the pulse laser light K is irradiated to the field 107 of the shape of Rhine shown in drawing 5 (b) and drawing 7 (a), and the crystalline silicon film of this field 107 is made into a melting condition. It recrystallizes the silicon film by which melting was carried out just behind that.

[0125] In this example 1, using a XeCl excimer laser (wavelength of 308nm, 40ns of pulse width) as a laser light at this time, the substrate was heated at 200-459 degrees C, for example, 400 degrees C, at the time of an exposure, and it considered as the exposure conditions irradiated by energy density 200 - 600 mJ/cm33, for example, 400 mJ/cm.

[0126] After the silicon film of the field 107 irradiated when pulse laser light was irradiated fuses momentarily, it recrystallizes in the direction shown by the arrow head M by drawing 5 (b) from the non-irradiating field of the circumference to the field 107 to which pulse laser light is irradiated. At this time, the silicon crystal of adjoining non-irradiating field 103b turns into seed crystal, and the crystalline silicon film 103f and 103h which carried out crystal growth is formed in the longitudinal direction shown by the arrow head M from the both-ends side of a field 107 reflecting that crystallinity. Before the crystal growth of the direction of arrow-head M starts, 103g of center sections will be in a supercooling condition, and they serve as a field which the crystalline nucleus generated and crystallized at random. In this example, the crystal growth distance to the longitudinal direction shown by the arrow head M was about 1.5 micrometers.

[0127] Here, in this example 1, pulse laser light was irradiated using the laser annealer shown in drawing 4 . Opening formed in the electric shielding mask at this time was made into 10micrometerx5mm magnitude. Therefore, the field 107 of the laser light K irradiated on field 103b on a glass substrate 101 also serves as the shape of a 10micrometerx5mm long rectangle.

[0128] Drawing 5 and drawing 7 explained the case where the silicon film was solidified by the pulse laser light irradiated by the electric shielding mask 41 from one of opening 41a by which two or more formation was carried out.

[0129] And as shown in drawing 4 , where the pulse laser light K is irradiated, the scan of the pulse laser light K to a glass substrate 101 is performed by moving a glass substrate 101 in the direction of C' with constant speed. The migration length of a glass substrate 101 is set to scanning pitch P in the pulse period by which the pulse laser light at this time is not irradiated. Scanning pitch P is prescribed by the passing speed to the direction of C' of a glass substrate 101, and the oscillation frequency of the pulse laser light K in this example. In the laser annealer shown in drawing 4 , since a glass substrate 101 is moved, when it sees from a glass substrate 101, the scanning direction of the pulse laser light K and the migration direction C of a glass substrate 101 turn into hard flow.

[0130] Drawing 5 (c) shows the condition of the glass substrate 101 when irradiating the 2nd pulse laser light. two -- a time -- a pulse laser -- light -- irradiating -- having -- a field -- 107 -- ' -- one -- a time -- a pulse laser -- light -- K -- an exposure -- from -- an arrow head -- C -- a direction -- a scanning pitch -- P -- only -- scanning -- having -- drawing 5 -- (-- c --) -- being shown -- as -- one -- a time -- an exposure -- a field -- from -- a scanning pitch -- P -- only -- caudad -- having shifted -- a field -- 107 -- ' -- a pulse laser -- light -- K -- irradiating -- having .

[0131] And field 107' by which the pulse laser light K was irradiated recrystallizes along the direction of arrow-head M' reflecting the crystallinity of an adjoining non-irradiating field, after melting is carried out. consequently -- a longitudinal direction -- having recrystallized -- a pair -- a field -- 103 -- f -- ' -- and -- 103 -- h -- ' -- the -- a center section -- setting -- being random -- karyogenesis -- having crystallized -- a field -- 103 -- g -- ' -- forming -- having . at this time, with the scanning direction C, 103f [ of fields of the opposite side ]' was crystallized so that the crystal of 103f of fields crystallized by the exposure of the 1st pulse laser light might be succeeded, and as for 103f [ of this field ]', as for 103f of fields, crystal growth changed into the condition of having extended in the scanning direction C --

field 103i of a single crystal is formed mostly.

[0132] Thus, if the exposure of the pulse laser light K is sequentially scanned in scanning pitch P in the direction shown by the drawing Nakaya mark C, as shown in drawing 5 (d) and drawing 7 (b), field 103i which changed into the single crystal condition mostly is extended further, it will reach far and wide and a single crystal field will be formed.

[0133] In this example 1, the oscillation frequency of pulse laser light was set to 200Hz, and the time interval between the exposure of the 1st pulse laser light and the exposure of the 2nd pulse laser light was set to 5msec. Moreover, as scanning pitch [ of pulse laser light ] P, it could be 0.5 micrometers in the range of 0.1-1.5 micrometers. When width of face of the laser beam to the scanning direction of pulse laser light is set to 10 micrometers at this time, in one point of the arbitration of field 103b, a total of 20 pulse laser exposures will be performed. However, since the crystallized state of field 103i is specified reflecting the crystallized state when crystallizing in the time of the exposure of the pulse laser light of the last round in this case, the exposure of the pulse laser light of the last round becomes the most important.

[0134] Thus, if formed field 103i is seen in micro, it constitutes the crystal grain of the shape of Rhine shown by N from drawing 5 (d) and drawing 7 (b) along the scanning direction C at the time of irradiating pulse laser light. this crystal grain -- EBSP -- according to observation of two-dimensional crystal-face bearing using law, the crystal grain of the shape of each Rhine was not independent, and it stood in a row in the almost same field bearing -- it is in the single crystal condition mostly, and the less than 5-degree small angle tilt boundary is formed in the grain boundary section of Rhine-like crystal grain. Moreover, the continuity of a grid is also maintained mostly and it is in the condition that 80% or more of atom is connected in each grain boundary section.

[0135] Next, as shown in drawing 7 (f), using field 103i mostly crystallized by the single crystal condition, by removing the silicon film of an unnecessary part, separation between components is performed and crystalline silicon film 111p of the desired island-shape configuration used as the active region of P type TFT is formed in 111n of crystalline silicon film which serves as an active region of N type TFT behind, and the back. In this example 1, these crystalline silicon film 111n and 111p was formed so that the migration direction of the carrier of next TFT and the direction of crystal growth by laser light scanning might become outline parallel.

[0136] Next, as shown in drawing 7 (d), the silicon oxide film 112 which is gate dielectric film is formed to 20-150nm thickness, for example, 100nm thickness, so that a 111n [ of crystalline silicon film used as an active region ] and 111p top may be covered, respectively. By using TEOS as a raw material, 150-600 degrees C, preferably, substrate temperature was warmed at 300-450 degrees C, and was deposited on the bottom of oxygen coexistence by RF plasma-CVD method in this example 1 at formation of this silicon oxide film 112. Then, by the sputtering method, high-melting metal is deposited on the silicon oxide film 112, patterning of this is carried out, and the gate electrode 113 located in the predetermined part on the crystalline silicon film 103 is formed. As a high-melting metal used in order to form the gate electrode 113, a tantalum (Ta) and a tungsten (W) are desirable. In this example 1, the gate electrode 113 was formed so that the thickness which doubled Ta by which the nitrogen of a minute amount was added, and two layers of pure Ta using the two-layer structure which carried out the laminating might become 300-600nm, for example, 450nm.

[0137] Then, Lynn (P) 115 is poured in using the ion doping method. In this case, the gate electrode 113 serves as a mask and Lynn 115 is not poured in into 111n of crystalline silicon film of the part under the gate electrode 113, and 111p. In this example 1, using phosphoretted hydrogen (PH3) as doping gas which dopes Lynn 115, as doping conditions, acceleration voltage was made into 60-90kV, for example, 80kV, and the dose was made into 2x1015-8x1015cm-2, 5x1015cm-2 [ for example, ].

[0138] The field of the crystalline silicon film 111n and 111p where a mask is carried out to the gate electrode 113 by this process, and Lynn 115 is not poured in according to it turns into the channel fields 118n and 118p of TFT through a next process. Moreover, the field of the crystalline silicon film 111n and 111p with which Lynn 115 was poured in, without carrying out a mask to the gate electrode 113 turns into the source fields 119n and 119p of TFT, and the drain fields 120n and 120p through a next process. At this process, it becomes the impurity range of the N type in the N channel mold TFT by having poured in Lynn 115. That is, at this process, also in the P channel mold TFT installed complementary, Lynn 115 is poured into the N channel mold TFT to the source / drain field, and it has become impurity range 119n' of N type, and 120n'.

[0139] Next, as shown in drawing 7 (e), according to a photolithography process, the wrap photoresist 121 is formed and let gate-dielectric-film [ on 111n of crystalline silicon film used as the N type channel TFT ] 112, and 113n top of gate electrodes be a mask for selection doping not to pour in the impurity of P type.

[0140] And boron 116 is poured in by the ion doping method in this condition. In this example 1, it doped by impressing the acceleration voltage of 40-80kV, for example, 65kV, in the high-dose amount of 1x1016-5x1016cm-2, 2x1016cm-2 [ for example, ], using diboron hexahydride (B-2 H6) as doping gas for pouring in boron 116.

[0141] In this process, into crystalline silicon film 111p of the part under gate electrode 113p, since gate electrode 113p becomes a mask, boron 116 is not poured in. Moreover, in crystalline silicon film 111p of the field in which gate electrode 113p is not formed, boron 116 is doped throughout a period of gate-dielectric-film 112. consequently -- the

point -- a process -- N type -- an impurity -- it is -- Lynn -- pouring in -- having -- N type -- becoming -- **** -- the source -- a field -- 119 -- n -- ' -- and -- a drain -- a field -- 120 -- n -- ' -- being superfluous -- boron -- 116 -- pouring in -- having -- things -- being the so-called -- a counter -- doping -- making -- having -- a result -- a property -- reversed -- the P type impurity ranges 119p and 120p -- becoming . Thus, the N channel mold TFT and the P channel mold TFT can be formed on the same substrate, respectively.

[0142] Next, as shown in drawing 7 (f), after removing the photoresist 121 prepared as a mask for selection doping, the trap of the nickel contained to this field by Lynn included to each source / drain field of TFT of N type and P type is carried out by performing heat-treatment over several hours - dozens of hours as 500-600-degree C temperature conditions under an inert atmosphere, for example, nitrogen gas atmosphere mind. And as shown in drawing 7 (f) at arrow-head 122q, the nickel which exists in the channel field is moved to adjoining source fields 119n and 119p and drain fields 120n and 120p, respectively. Consequently, the concentration of the nickel which exists in a channel field can be reduced sharply.

[0143] Here, each TFT has been arranged so that it may become in the direction shown in drawing 5 (d). That is, it carries out as [ serve as / the scanning direction C of the pulse laser light at the time of irradiating pulse laser light and the direction Q to which nickel is moved / outline parallel ]. Thus, by making TFT arrangement, the direction N of the crystal grain of the Rhine-like crystal in a channel field and the migration direction Q of nickel turn into this direction, and it is carried out, without migration of nickel to a source field and a drain field exceeding the different grain boundary. Consequently, the migration effectiveness of nickel can improve and the amount of survival of the nickel in a channel field can be reduced sharply.

[0144] When the concentration of the nickel which remains all over the channel field at this time was measured according to secondary ion mass spectrometry (SIMS), the concentration of the nickel in the channel field which were 5x1017 - about three 1x1018 atoms/cm before performing this process was reduced by about three 5x1016 atoms/cm.

[0145] On the other hand, activation of a source field and a drain field is performed to coincidence by this heat-treatment. In the sheet resistance of the N type impurity range manufactured according to this process, the sheet resistance of 0.5-1kohm/** and the P type impurity ranges 119p and 120p became 1 - 2kohm/**. Furthermore, baking processing of gate dielectric film is performed to coincidence by this heating down stream processing, and improvement in the bulk property of gate dielectric film itself and the interface property between the crystalline silicon film and gate dielectric film is achieved.

[0146] Next, as shown in drawing 7 (g), the silicon oxide film of 900nm thickness is formed, using a plasma-CVD method as an interlayer insulation film 123. And a contact hole 121 is formed in the part applicable to the source fields 119n and 119p and the drain fields 120n and 120p on the crystalline silicon film of each TFT of an interlayer insulation film 123, respectively. The electrode and the wiring 124 electrically connected to the source / drain field of TFT are formed in the contact hole 121 formed in the interlayer insulation film 123 with a metallic material, for example, the bilayer film of titanium nitride and aluminum. Then, the N channel mold TFT125 and the P channel mold TFT126 are completed under the hydrogen ambient atmosphere of one atmospheric pressure by performing annealing over 1 hour as 350-degree C temperature conditions. Furthermore, in order to protect TFT 125 and 126 of N type and P type if needed, the protective coat which consists of silicon nitride film etc. may be prepared on this.

[0147] The high value to which each electric field effect mobility of TFT is said as 450-500cm2/Vs with N type TFT125, and says the process explained above as 150-200cm2/Vs with P type TFT126 in the CMOS structure circuit pass was acquired, and, as for threshold voltage, about -1.5V and a very good property were acquired about 1.0V and with P type TFT126 with N type TFT125. And it was able to hold down with electric field effect mobility, and was able to hold down to about **0.2V with threshold voltage about **10% also about dispersion in the property which poses a problem with the semiconductor device obtained by the conventional crystallization approach. In addition, the above property is acquired by performing measurement of 30 points in the substrate of 400mmx320mm magnitude.

[0148] Moreover, also about increase and dispersion of the leakage current in the OFF field of TFT in which especially survival of a catalyst element poses a problem, an abnormality point was not seen but it was able to decrease even on level comparable as the case where a catalyst element is not used. For this reason, the manufacture yield can be improved greatly. Furthermore, even if it performed repeat measurement and durability test by bias or temperature stress, most property degradation was not seen, but as compared with TFT obtained by the conventional crystallization approach, it was reliable, and the circuit by which the electrical property was stabilized was obtained.

[0149] (Example 2) This example 2 explains the process which is used for a part for the driver line of the liquid crystal display of a active-matrix mold, and a picture element part, and a thin film integrated circuit and which manufactures the N channel mold TFT on a glass substrate.

[0150] Drawing 8 is the top view of the semiconductor device for explaining the process which manufactures N type TFT of this example 2.

[0151] Drawing 9 (a) - (c) explains the process which manufactures N type TFT of this example 2 for every process, respectively, and shows the sectional view which meets the A-A' line of drawing 8 . Moreover, drawing 10 (a) - (d)

explains the process which manufactures N type TFT of this example 2 for every process, respectively, and shows the sectional view which meets the B-B' line of drawing 8 .
[0152] In order to manufacture N type TFT of this example 2 and to prevent first that an impurity is spread from a glass substrate 201 according to a next process as shown in drawing 9 (a), the substrate film 202 which consists of silicon oxide which has about 300-500nm thickness by the sputtering method or the plasma-CVD method is formed on a glass substrate 201. Next, 20-80nm in thickness and the 40nm intrinsic (I-beam) amorphous silicon film (a-Si film) 203 are formed using a plasma-CVD method.
[0153] Subsequently, the mask 204 which deposited insulating thin films, such as silicon oxide film or silicon nitride film, over the whole surface on the a-Si film 203 is formed. In this example 2, the silicon oxide film was deposited by depositing using RF plasma-CVD method under oxygen coexistence by using TEOS (Tetra Ethoxy Ortho Silicate) as a raw material on the a-Si film 203. As for the thickness of the silicon oxide film in this case, it was desirable that it is the range of 100-400nm, and it set thickness of the silicon oxide film to 150nm in this example 2. The a-Si film 203 is exposed in the field 200 to which the slit-like through hole was formed in this mask 204, and the through hole was formed in it. By the through hole formed in this mask 204, as shown in drawing 8 , the field 200 which the a-Si film 203 exposed becomes slit-like. Parts other than field 200 are in the condition that it is not exposed of the a-Si film 203 with a mask 204. In this case, as for the Rhine width of face L of each field which the a-Si film 203 has exposed, it was desirable to be set as the range of 1-15 micrometers, and it set it to 8 micrometers by this example 2.
[0154] Next, the nickel 205 of a minute amount is added on the front face of the a-Si film 203 and a mask 204. Addition of nickel 205 held the solution which dissolved nickel 205 on the a-Si film 203 and a mask 204, and was performed by extending a nickel solution on a substrate by the spinner, and making it dry. In this example 2, nickel acetate was used as a solute and ethanol was used as a solvent, and it adjusted so that the nickel concentration in a solution might be set to 10 ppm. the concentration of the added nickel 205 -- total reflection X-ray fluorescence (TRXRF) -- it was about two 5x1013 atoms/cm by the measurement using law.
[0155] Next, as shown in drawing 9 (b), whenever [ stoving temperature ] is annealed over 11 hours in this condition as 530-600 degrees C, for example, 580 degrees C, under an inert gas ambient atmosphere, for example, nitrogen-gas-atmosphere mind.
[0156] Under the present circumstances, in the field in which nickel 205 was added on the front face of the a-Si film 203, silicide-ization of the nickel 205 which exists in the front face of the a-Si film 203 takes place, the a-Si film 203 crystallizes by using this silicide as a nucleus, and field 203a of the crystalline silicon film is formed in this field 200. And succeedingly, in the boundary region of a field 200, as an arrow head R shows, field 203b of the crystalline silicon film with which the crystal grew is formed in a longitudinal direction (direction parallel to a substrate) from a field 200. Moreover, it remains in the outside of field 203b as 203d of fields where the amorphous silicon film remained.
[0157] When crystallization goes to a longitudinal direction from each field 200, boundary section 203c with which the crystal which grew up to be a longitudinal direction from each field collided is formed in the abbreviation central part of each field 200.
[0158] Since the mask of the nickel 205 attached on the mask is carried out with a mask 204, it does not reach the lower layer a-Si film 203, and it does not participate in crystallization of the a-Si film 203. The nickel concentration in field 203b of the crystalline silicon film which carried out crystal growth to such a longitudinal direction was 5x1017 - about three 1x1018 atoms/cm, and the nickel concentration in field 203a of the crystalline silicon film in which it was added and nickel 205 carried out crystal growth was about three 1x1019 atoms/cm directly. Moreover, the die length to which crystal growth of the direction parallel to the glass substrate 201 shown by the arrow head R was carried out on the occasion of the above-mentioned crystal growth was about 130 micrometers in the longest part.
[0159] Next, as shown in drawing 9 (c), etching removal of the mask 204 is carried out. In this example 2, the wet etching using the buffered fluoric acid (BHF) of 1:10 which has the selectivity of etching sufficient between the lower layer silicon film 203 as etchant removed the mask 204.
[0160] Next, as shown in drawing 10 (d), the crystalline silicon film is formed by recrystallizing after that by making into a melting condition the field where pulse laser light was irradiated in the shape of Rhine in the direction which intersects perpendicularly with a field 200, and pulse laser light was irradiated.
[0161] In this example 2, using a XeCl excimer laser (wavelength of 308nm, 40ns of pulse width) as a pulse laser light at this time, the substrate was heated at 200-450 degrees C, for example, 400 degrees C, at the time of the exposure of pulse laser light, and it considered as the exposure conditions which irradiate energy density by 200 - 600 mJ/cm22, for example, 400 mJ/cm.
[0162] In the example 2 as well as an example 1, growth of field 203j which inherited the crystallinity of the field crystallized by the exposure of the pulse laser light S of the preceding paragraph is performed by scanning the pulse laser light S of a long configuration sequentially in the direction of the arrow head U in drawing 4 .
[0163] Differing from the case of an example 1 is the point that crystallization by the exposure of the pulse laser light S is performed also to 203d of amorphous silicon film fields of the outside exceeding field 203b which carried out crystal

growth to the longitudinal direction with nickel 205. Also in this case, in order that the crystallinity in that case may be inherited since melting solidification of the silicon film by the exposure of the first pulse laser light S is performed to field 203b, and melting solidification of the silicon film by the exposure of the subsequent pulse laser light S may progress, also in field 203c used as the amorphous silicon film, quality crystalline silicon film 203j is formed.
[0164] In this example 2, scan pitch P of the pulse laser light S carried out to 0.1-1.5 micrometers, for example, 0.5 micrometers. Moreover, width of face of the laser-beam light S to the scanning direction of the pulse laser light S was set to 10 micrometers. In this case, a total of 20 exposures of the pulse laser light S will be performed about one point of the arbitration on the silicon film. However, since the exposure of the pulse laser light S of the last round crystallizes in fact reflecting the crystallinity of the adjoining field crystallized by the exposure of the pulse laser light S of the preceding paragraph among the exposures of the pulse laser light S by which a multiple-times exposure is carried out to each location on the silicon film, it is the most important when the exposure of the pulse laser light S of the last round specifies the crystallinity of the crystalline silicon film.
[0165] Field 203j formed by scanning such a pulse laser light S sequentially is constituted by the Rhine-like crystal grain along the scanning direction of pulse laser light. this crystal grain -- EBSP -- according to observation of two-dimensional crystal-face bearing using law, the crystal grain of the shape of each Rhine became the almost same field bearing across the grain boundary -- it is in the single crystal condition mostly, and the less than 5-degree small angle tilt boundary is formed in the grain boundary section of Rhine-like crystal grain.
[0166] Next, as shown in drawing 10 (c), by removing the silicon film of other unnecessary parts using field 203j which was formed from field 203b which grew with nickel 205 and which changed into the single crystal condition mostly using field 203j mostly crystallized by the single crystal condition, separation between components is performed and the crystalline silicon film 211 formed in desired island shape is formed.
[0167] Next, as shown in drawing 10 (c), the silicon oxide film 212 which is gate dielectric film is formed to 20-150nm thickness, for example, 100nm thickness, so that the crystalline silicon film 211 top used as an active region may be covered. By using TFOS as a raw material, under oxygen coexistence, 150-600 degrees C, substrate temperature was warmed at 300-450 degrees C, and was preferably, decomposed and deposited by RF plasma-CVD method in this example 2 at formation of this silicon oxide film 212. Or by using TEOS as a raw material, 350-600 degrees C of substrate temperature may be preferably warmed at 400-550 degrees C, and the silicon oxide film 212 may be formed in the bottom of ozone gas coexistence with a reduced pressure CVD method or an ordinary pressure CVD method. After membrane formation of the silicon oxide film 212, in order to improve the bulk property of silicon oxide film 212 the very thing, and the interface property of the crystalline silicon film 211 and the silicon oxide film 212, heat treatment over 1 - 4 hours was performed on 400-600-degree C temperature conditions under the inert gas ambient atmosphere. Then, by the sputtering method, aluminum is formed to 400-800nm thickness, for example, 600nm thickness, patterning of this is carried out, and the gate electrode 213 located in the predetermined part which becomes the crystalline silicon film 212 top is formed. Subsequently, an oxide layer 214 is formed on a front face by anodizing the front face of the gate electrode 213 which consists of this aluminum. In the ethylene glycol solution with which the tartaric acid was contained 1 to 5%, this anodization raises an electrical potential difference to 220V, after passing a fixed current first, and it is acquired by holding in that condition for 1 hour. The thickness of the obtained oxide layer 214 was 200nm. In addition, in a next ion doping process, since this oxide layer 214 serves as thickness which forms an offset gate electrode, it can determine the die length of an offset gate field according to the above-mentioned anodic oxidation process.
[0168] Then, Lynn which is an impurity is poured in using the ion doping method. In this case, the gate electrode 213 and oxide layer 214 which were formed on the silicon oxide film 212 serve as a mask, and Lynn is not poured in into the crystalline silicon film 211 applicable to the part under the gate electrode 213. In this example 2, using phosphoretted hydrogen (PH3) as doping gas which dopes Lynn, as doping conditions, acceleration voltage was made into 60-90kV, for example, 80kV, and the dose was made into 1x1015-8x1015cm-2, 2x1015cm-2 [ for example, ].
[0169] The field of the crystalline silicon film 211 where a mask is carried out to the gate electrode 213 by this process, and Lynn is not poured in according to it turns into a channel field of TFT behind. Moreover, the field of the crystalline silicon film 211 with which Lynn was poured in, without carrying out a mask to the gate electrode 213 turns into the source field 219 of TFT, and the drain field 220 behind. At this process, the impurity range of the N type in the N channel mold TFT is formed by having poured in Lynn.
[0170] Since the direction (the direction of the source field 219 -> drain field 220) where a carrier flows to actuation of TFT by arranging TFT, and the direction of Rhine of the crystal grain of the shape of Rhine which constitutes the channel field 218 (the growth direction T) are parallel at this time as shown in drawing 8 , TFT which has higher mobility is obtained.
[0171] Next, the crystallinity of the part into which crystallinity deteriorated according to the introductory process of the above-mentioned impurity is improved at the same time it activates the impurity which carried out the ion implantation by irradiating the laser light V and performing annealing, as shown in drawing 10 (c).

[0172] under the present circumstances -- as the laser light V -- a XeCl excimer laser (wavelength of 308nm, 40ns of pulse width) -- using -- energy density -- 150 - 400 mJ/cm2 -- it considered as 200 - 250 mJ/cm2 preferably. Thus, the sheet resistance of the formed N type impurity range became 200-500ohms / **.
[0173] Next, as shown in drawing 10 (d), about 600nm the silicon oxide film or silicon nitride film of thickness is formed, and it considers as an interlayer insulation film 223. When forming the silicon oxide film as an interlayer insulation film 223, the good silicon oxide film excellent in step coverage nature is formed by using the plasma-CVD method under oxygen coexistence, or the reduced pressure CVD method under ozone coexistence by using TEOS as a raw material. Moreover, when forming the silicon nitride film as an interlayer insulation film 223, the silicon nitride film is formed by using a plasma-CVD method by making SiH4 and NH3 into material gas. This silicon nitride film can supply a hydrogen atom to the interface of an active region and gate dielectric film, and can reduce the azygos joint hand of degrading a TFT property.
[0174] Subsequently, contact hole 223a which arrives at these fields is formed in the part applicable to the source field 219 and the drain field 220 on the crystalline silicon film 211 of TFT of an interlayer insulation film 223. The electrode and the wiring 224 connected electrically are formed in the source field 219 and the drain field 220 of TFT with a metallic material, for example, the bilayer film of titanium nitride and aluminum, at contact hole 223a formed in the interlayer insulation film 223. The titanium nitride film is prepared as barrier film for preventing that aluminum is spread in a semi-conductor layer. Moreover, what is necessary is just to use for the drain electrode 220 the pixel electrode which consists of transparence electric conduction film, such as ITO, in using this TFT for pixel switching of a liquid crystal display. Furthermore, what is necessary is to form a contact hole also on the gate electrode 213, and just to prepare wiring needed for this contact hole, in using this TFT225 for a thin film integrated circuit etc.
[0175] Annealing over 1 hour is performed at the last as 350-degree C temperature conditions under the steam ambient atmosphere of one atmospheric pressure, and TFT225 of a request is completed. In addition, in order to protect TFT225, protective coats, such as silicon nitride film, may be prepared further.
[0176] Electric field effect mobility turned into 450cm2/Vs extent, threshold voltage turned into about 1.0V, and the engine performance of TFT225 manufactured through the process explained above improved remarkably. Furthermore, it was able to hold down with electric field effect mobility, and was able to hold down to about **0.2V with threshold voltage about **10%, respectively. In addition, the above property is acquired by performing measurement of 30 points in the substrate of 400mmx320mm magnitude.
[0177] Moreover, although the migration direction of the carrier of TFT and the direction of crystal growth by the scan of an exposure of pulse laser light are acquired about TFT designed so that it might become parallel mutually, the above-mentioned property Also in TFT designed so that the migration direction and the direction of crystal growth of a carrier of TFT might become perpendicularly mutually Electric field effect mobility was able to turn into 350cm2 / Vs extent, threshold voltage was able to turn into about 1.2V, and it was fully able to become high performance as compared with TFT obtained by the conventional approach, and dispersion in the property within a substrate was able to be suppressed small similarly.
[0178] Furthermore, even if TFT of this example 2 performs repeat measurement and durability test by bias or temperature stress, most property degradation is not seen but is reliable. Moreover, also about increase and dispersion of the leakage current in the OFF field of TFT in which especially the residual of a catalyst element poses a problem, there is no abnormality point and it was able to decrease to the level of number pA extent comparable as the case where a catalyst element is not used. For this reason, the manufacture yield can be improved greatly.
[0179] Furthermore, if a liquid crystal panel is manufactured using TFT of this example 2, as compared with the liquid crystal panel using TFT manufactured by the conventional manufacture approach, display nonuniformity is small, and the pixel defect by TFT leak also has it, and it can manufacture a liquid crystal panel with high display grace with a high contrast ratio. [ very little ]
[0180] (Example 3) This example 3 explains the case where continuous-wave-laser light is used, as a laser light which irradiates the silicon film. In addition, in this example 3, the illustration is omitted noting that the drawing used for examples 1 and 2 is referred to, since continuous-wave-laser light was used and also it is the same as that of the above-mentioned examples 1 and 2 and an outline.
[0181] First, the substrate insulator layer which consists of silicon oxide film etc. is formed on a glass substrate like examples 1 and 2, and the amorphous silicon film (a-Si film) is formed on the substrate insulator layer.
[0182] Next, after depositing insulating thin films, such as a silicon oxide curtain or silicon nitride film, over the whole surface on this amorphous silicon film, the mask which has opening into a predetermined part is formed by carrying out patterning. And a catalyst element is alternatively introduced on the amorphous silicon film with which this mask was formed using opening of a mask (the condition of a glass substrate that the amorphous silicon film at this time was formed shall carry out drawing 6 (a) reference, and refer to the explanation in an example 1 for it about the introductory approach of a catalyst element).
[0183] Next, it anneals and a longitudinal direction is made to carry out crystal growth by making whenever [ stoving

temperature ] into 530-600DO in this condition from the field of the amorphous silicon film with which the catalyst element was introduced under an inert gas ambient atmosphere, for example, nitrogen-gas-atmosphere mind. As for the condition at this time, drawing 6 (c) and drawing 9 (c) are referred to. Moreover, superficially, drawing 1 (a) and drawing 5 (a) are referred to.
[0184] Next, it scans to the crystalline silicon film of this condition, irradiating continuous-wave-laser light continuously. Thereby, this crystalline silicon film is crystallized along the scanning direction of laser light. The scanning direction of this laser light is the same as that of the scan method of the pulse laser light of examples 1 and 2. As a continuous-wave-laser light irradiated by the crystalline silicon film, the continuous-oscillation YAG laser light of diode excitation was used. Moreover, wavelength was 532nm and power fluctuation was 1% or less. Furthermore, the output of a continuous-oscillation YAG laser is 10W, and the scan speed was made into 50 - 200 cm/sec, for example, 100 cm/sec, to the substrate. In the crystalline silicon film, the part irradiated by the exposure of continuous-wave-laser light is fused, the interface of the silicon of a solid state and the silicon of a liquefied condition arises on the boundary of the exposure field of laser light, and a non-irradiating field, and when the interface moves continuously with the scan of laser light, the grain boundary which met the one direction reflecting the crystallinity of the original crystalline silicon film grows.
[0185] Then, the unnecessary part of the crystalline silicon film is removed, separation between components is performed, and patterning is performed to the island shape which serves as an active region (the source and a drain field, channel field) of TFT behind. TFT is completed through the process as the above-mentioned examples 1 and 2 that the following processes are the same.
[0186] At this example 3, the crystalline silicon film is recrystallized in the longitudinal direction (the direction of laser light scanning) using continuous-wave-laser light in this way. In this example 3, it became clear that a higher TFT property is acquired as compared with the examples 1 and 2 which used pulse laser light. Specifically, the electric field effect mobility more than 600cm2/Vs was obtained with the N channel mold TF.
[0187] As mentioned above, although the semiconductor device based on this invention was concretely explained based on three examples, this invention is not limited to the three above-mentioned examples, and various kinds of deformation based on the technical thought of this invention is possible for it.
[0188] For example, in the three above-mentioned examples, although the approach and the DC sputtering method of low power which apply the water solution of nickel salt to the front face of the amorphous silicon film are adopted, before forming the amorphous silicon film, the upper amorphous silicon film can also be crystallized by introducing nickel into the front face of the substrate film alternatively. That is, the catalyst element which promotes crystallization of amorphous silicon is introduced from the amorphous silicon film bottom, crystal growth of it may be carried out from the front-face side of the amorphous silicon film, it is introduced into the bottom, and may carry out crystal growth from the rear-face side of the amorphous silicon film.
[0189] Moreover, various approaches besides the approach of the above-mentioned example can be used as the introductory approach of nickel. For example, the approach of carrying out thin film formation with the approach of diffusing from SiO2 film, the approach of introducing directly by the ion doping method, vacuum deposition, and plating etc. can be used, using an SOG (spin-on glass) ingredient as a solvent in which nickel salt is dissolved.
[0190] Furthermore, cobalt besides nickel, iron, palladium, platinum, copper, and gold can be used as a catalyst element.
[0191] Moreover, in the above-mentioned examples 1 and 2, a KrF excimer laser with a wavelength [ besides / which used for the above-mentioned examples 1 and 2 the crystalline silicon film crystallized with the catalyst element as a pulse laser light which carries out melting solidification / a XeCl excimer laser with a wavelength of 308nm ] of 248nm, an ArF excimer laser with a wavelength of 198nm, etc. may be used. Moreover, although it becomes the wavelength of a visible region, it is also possible to use an YAG laser. Moreover, the effectiveness same also as configurations other than the shape of an above long rectangle is acquired also about the exposure configuration of the pulse laser light irradiated.
[0192] Moreover, even if it applies a driver built-in thermal head, others, for example, a contact type image sensor, the organic system EL, etc. to the driver built-in component write-in [ optical ] used as the light emitting device or a display device, a three-dimensional IC, etc. as equipment with which the semiconductor device of this invention is applied, a high speed and high resolution-ization are [ these components ] realizable. [ substrate / for liquid crystal displays / active-matrix mold ]
[0193] Furthermore, the semiconductor device of this invention is not restricted to the MOS transistor explained in the above-mentioned example 1, but can apply broadly a bipolar transistor, a static induction transistor, etc. which made the crystalline semi-conductor component material to a semi-conductor process at large.
[0194]
[Effect of the Invention] The semiconductor device and its manufacture approach of this invention use as seed crystal the field by which the catalyst element of the minute amount which promotes crystallization of the amorphous silicon

film was introduced, and solid phase growth was carried out in the longitudinal direction to the substrate. In order to make into an active region the field as for which crystal growth was carried out to the outline one direction by the melting solidification process by carrying out an optical exposure to this field by which solid phase growth was carried out, are highly efficient. The semiconductor device of the stable property with little dispersion can be realized, and a high performance semiconductor device with a high degree of integration can be manufactured in a simple manufacture process.

[0195] Furthermore, in the production process using the manufacture approach of this invention, the rate of an excellent article can be improved greatly and low cost-ization of goods can be attained. In the liquid crystal display with which improvement in the switching characteristic of the pixel switching TFT of a active-matrix substrate, and high-performance-izing and high integration of TFT which constitutes the circumference drive circuit section are demanded especially, it can be satisfied with coincidence of improvement in these properties, it can realize the driver monolithic mold active-matrix substrate which constitutes the active-matrix section and the circumference drive circuit section on the same substrate, and can attain modular miniaturization, high-performance-izing, and low-cost-ization.

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[Translation done.]

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] (a) - (d) is a top view which explains the manufacture approach of the semiconductor device of this invention for every process, respectively.
[Drawing 2] When manufacturing the semiconductor device of this invention, it is the schematic diagram showing the laser annealer used for the melting solidification process of the silicon film by the exposure of pulse laser light.
[Drawing 3] It is the explanatory view showing the pulse laser luminous-intensity profile which an electric shielding mask is penetrated and is irradiated on a substrate.
[Drawing 4] When manufacturing the semiconductor device of this invention, it is the schematic diagram showing other laser annealer used for the melting solidification process of the silicon film by the exposure of pulse laser light.
[Drawing 5] (a) - (d) is a top view which explains the process which manufactures the CMOS structure which constituted N type TFT and P type TFT of an example 1 complementary, respectively for every process.
[Drawing 6] (a) - (c) explains the process which manufactures the structure of drawing 5 (a) for every process, respectively, and shows the sectional view which meets the A-A' line of drawing 5 (a).
[Drawing 7] (a) - (g) explains the process which manufactures the structure shown in drawing 5 (b) - (d), respectively for every process of the, and shows the sectional view which meets the B-B' line of drawing 5 (b) - (d).
[Drawing 8] It is a top view for explaining the process which manufactures N type TFT of an example 2.
[Drawing 9] (a) - (c) explains the process which manufactures N type TFT shown in drawing 8 , respectively for every process, and shows the sectional view which meets the A-A' line of drawing 8 .
[Drawing 10] (a) - (d) explains the process which manufactures N type TFT of an example 2 for every process, respectively, and shows the sectional view which meets the B-B' line of drawing 8 .
[Drawing 11] It is the sectional view showing roughly the condition of the crystal grain of the crystalline silicon film obtained by the approach of the ** table No. 505241 [ 2000 to ] official report.
[Drawing 12] It is the crystallization art indicated by the ** table No. 505241 [ 2000 to ] official report, and is the top view showing the result crystallized as a configuration which includes a crookedness configuration in the configuration of the mask for forming the exposure field where a laser beam is irradiated.
[Drawing 13] It is the top view showing the crystalline silicon film obtained by the approach of JP,11-260723,A.
[Drawing 14] It is the sectional view showing roughly the change of state of the silicon film at the time of irradiating continuous-wave-laser light and the silicon film.
[Drawing 15] It is the schematic diagram of photograph substitution showing the fine structure of the semiconductor device of this invention.
[Description of Notations]
1 Each Catalyst Element Installation Field
3 Domain Boundary
4 Crystal Domain
6 Field
8 Field
9 Field
10 Field
11 Field
12 Field
14 Field
15 Field
16 Growth Boundary Section
17 Active Region
100 Field

101 Glass-Substrate
102 Substrate Film
103 Amorphous Silicon Film
104 Mask
105 Nickel
107 Field
107' Field
111n, 111p Crystalline silicon film
118n, 118p Channel field
119n, 119p Source field
120n, 120p Drain field
125 N Channel Mold TFT
126 P Channel Mold TFT
200 Field
201 Glass Substrate
202 Substrate Film
203 Amorphous Silicon Film
204 Mask
205 Nickel
211 Crystalline Silicon Film
213 Gate Electrode
214 Oxide Layer
218 Channel Field
219 Source Field
220 Drain Field
223 Interlayer Insulation Film
224 Electrode and Wiring
225 TFT

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CLAIMS

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[Claim(s)]
[Claim 1] It is the semiconductor device by which the active region was formed with the silicon film which has crystallinity on the substrate which has an insulating front face. This active region The field by which solid phase growth was carried out along the one direction is used as seed crystal from the field where the catalyst element of the minute amount which promotes crystallization of the amorphous silicon film was introduced. The semiconductor device characterized by being formed in an outline one direction with the silicon film which has the crystallinity by which crystal growth was carried out by carrying out melting solidification of this field by which solid phase growth was carried out.
[Claim 2] The semiconductor device according to claim 1 whose crystal growth direction of the silicon film which has the crystallinity by which crystal growth was carried out by [ said ] carrying out melting solidification is a direction which carries out an outline rectangular cross to the crystal growth direction of said field by which solid phase growth was carried out.
[Claim 3] It is the semiconductor device according to claim 1 which has the field bearing as the crystal grain group of the adjoining shape of other Rhine where the crystal grain group of the shape of this Rhine is almost the same by forming said active region of the crystal grain group of the shape of Rhine located in a line with the outline one direction along the crystal growth direction of the field by which crystal growth was carried out by [ said ] carrying out melting solidification.
[Claim 4] The semiconductor device according to claim 3 with which the gap of field bearing of each shape of said Rhine crystal grain between groups is less than 5 degrees.
[Claim 5] It is the semiconductor device according to claim 1 with which said active region was formed of the crystal grain group of the shape of Rhine located in a line with the outline one direction along the crystal growth direction of the field by which crystal growth was carried out by [ said ] carrying out melting solidification, and, as for the grain boundary of the crystal grain group of this shape of each Rhine, at least 80% or more of silicon atom is connected in the shape of a grid on atomic level.
[Claim 6] Said active region is a semiconductor device according to claim 1 with which it is formed of the crystal grain group of the shape of Rhine located in a line with the outline one direction along the crystal growth direction of the field by which crystal growth was carried out, and the small angle tilt boundary is formed between the grain boundaries of this shape of each Rhine by [ said ] carrying out melting solidification.
[Claim 7] Said small angle tilt boundary is a semiconductor device according to claim 6 with which the angle of rotation of superficial bearing between each crystal grain is less than 5 degrees.
[Claim 8] Said grain boundary is a semiconductor device according to claim 3 to 7 as which the location is specified by etching by the SEKOETCHINGU method.
[Claim 9] the inclination of field bearing of said crystal grain group, and the crystal orientation in the grain boundary -- EBSP -- the semiconductor device according to claim 3 to 7 which is the field measured by law.
[Claim 10] Said active region is a semiconductor device according to claim 1 to 7 currently formed so that it may become outline parallel to the direction along the crystal growth direction of the field by which crystal growth was carried out, and the grain boundary of each shape of said Rhine by carrying out melting solidification of the migration direction of the carrier which moves in said active region.
[Claim 11] The active region formed in said active region is a semiconductor device according to claim 1 to 10 which contains the nickel element which is a catalyst element by the concentration of 1x1016 - 5x1017 atoms/cm3.
[Claim 12] The process which introduces alternatively the catalyst element which promotes crystallization of the amorphous silicon film into some amorphous silicon film formed on the substrate which has an insulating front face, and by heat-treating this amorphous silicon film The process which this catalyst element makes carry out sequential crystallization from the contiguity part of the field introduced alternatively, and uses as the crystalline silicon film, The manufacture approach of the semiconductor device characterized by including the process which heats and carries out sequential recrystallization of it, scanning this crystalline silicon film in the predetermined direction, and the process

which forms an active region with the crystalline silicon film which it this recrystallized.
[Claim 13] For the crystalline silicon film crystallized by installation of said catalyst element, laser light is [ this crystallization direction ] the manufacture approach of a semiconductor device according to claim 12 of being heated by being scanned along the direction where it intersects perpendicularly.
[Claim 14] It is the manufacture approach of a semiconductor device according to claim 13 that said laser light is scanned along the direction where the field formed this shape of Rhine and in the shape of a stripe extends by introducing said catalyst element into the field formed the shape of Rhine, and in the shape of a stripe on the amorphous silicon film formed on the substrate which has said insulating front face.
[Claim 15] Each width of face of the field formed said shape of Rhine and in the shape of a stripe is the manufacture approach of a semiconductor device according to claim 14 currently formed in the range of 1-15 micrometers.
[Claim 16] The process which heats and carries out sequential recrystallization of it, scanning the crystalline silicon film crystallized by installation of said catalyst element in the predetermined direction is the manufacture approach of a semiconductor device according to claim 12 to 15 performed by carrying out sequential recrystallization reflecting the crystallinity of the field which the pulse laser light of the preceding paragraph recrystallized by scanning a substrate or pulse laser light to an one direction, irradiating pulse laser light at this crystalline silicon film.
[Claim 17] Among said pulse laser light irradiated while being scanned by said crystalline silicon film in the fixed direction, at least the pulse laser light of the 1st step The pulse laser light of the 2nd step after the field crystallized by installation of said catalyst element irradiated and the exposure of the pulse laser light to this field was performed is the manufacture approach of a semiconductor device according to claim 16 irradiated by the field to which crystal growth by installation of a catalyst element is not performed.
[Claim 18] The scanning pitch of said pulse laser light is the manufacture approach of a semiconductor device according to claim 16 or 17 set below to the die length which the field of the crystalline silicon film fused at the time of the exposure of said pulse laser light can recrystallize reflecting the crystallinity of the crystalline silicon film of an adjoining unmelting field.
[Claim 19] The scanning pitch of said pulse laser light is the manufacture approach of a semiconductor device according to claim 18 which is 0.1 micrometers - 1.5 micrometers.
[Claim 20] Said pulse laser light is the manufacture approach of a semiconductor device according to claim 16 to 19 which is long along the perpendicular direction to the direction scanned.
[Claim 21] The profile of the beam reinforcement of said pulse laser light on the strength is the manufacture approach of a semiconductor device according to claim 16 to 20 of said pulse laser light that the profile of the opposite side of a scanning direction on the strength falls from fixed reinforcement up to 0 reinforcement rapidly at least.
[Claim 22] For the scanning direction, said pulse laser light is the manufacture approach of a semiconductor device according to claim 21 irradiated using a laser radiation means to have the electric shielding means which carries out the mask of a part of opposite side mechanically.
[Claim 23] The electric shielding means of said laser radiation means is the manufacture approach of a semiconductor device according to claim 22 which covers the range to which reinforcement falls the pulse laser light irradiated continuously from reinforcement required for melting of said crystalline silicon film at least.
[Claim 24] Said pulse laser light is the manufacture approach of a semiconductor device according to claim 16 to 23 irradiated by the reinforcement which said crystalline silicon film fuses over the whole film.
[Claim 25] Said pulse laser light is the manufacture approach of a semiconductor device according to claim 24 for which an excimer laser with a wavelength of 400nm or less is used and which is irradiated in the range in which the energy density to the front face of said crystalline silicon film serves as 200 - 600 mJ/cm2.
[Claim 26] The process which heats and carries out sequential recrystallization of it, scanning the crystalline silicon film crystallized by installation of said catalyst element in the predetermined direction is the manufacture approach of a semiconductor device according to claim 12 to 15 performed by carrying out sequential recrystallization reflecting the crystallinity of the field which continuous-wave-laser light recrystallized previously by scanning a substrate or continuous-wave-laser light to an one direction, irradiating continuous-wave-laser light at this crystal silicon film.
[Claim 27] The process which irradiates continuous-wave-laser light at said crystalline silicon film is the manufacture approach of a semiconductor device according to claim 26 that sequential recrystallization is performed while melting of the silicon film of an exposure field is carried out by this continuous-wave-laser light and the interface of the solid state in the silicon film and a liquid condition is moved with the scan of this continuous-wave-laser light.
[Claim 28] The manufacture approach of a semiconductor device according to claim 26 that solid state laser is used as said continuous-wave-laser light.
[Claim 29] Said active region is the manufacture approach of a semiconductor device according to claim 13 to 28 formed along the scanning direction of said laser light.
[Claim 30] The catalyst element which promotes crystallization of said amorphous silicon film is the manufacture approach of a semiconductor device according to claim 12 to 29 which is at least one element chosen from nickel, Co,

Fe, Pd, Pt, Cu, and Au.
[Claim 31] The process which introduces at least the element chosen from five groups B into the field of the crystalline silicon film except becoming an active region according to a next process after performing the process which carries out sequential recrystallization of said crystalline silicon film by scanning said laser light, To the field to which the element chosen from said five groups B by performing 2nd heat-treatment to this crystalline silicon film was introduced The manufacture approach of a semiconductor device according to claim 13 to 30 of moving said catalyst element and performing further the process which reduces the amount of said catalyst element contained to the field of the crystalline silicon film which serves as an active region according to a next process.
[Claim 32] The migration direction of said catalyst element moved by said 2nd heat-treatment is the manufacture approach of a semiconductor device according to claim 31 which is the scanning direction of said laser light, and outline parallel.
[Claim 33] The element chosen from said five groups B is the manufacture approach of a semiconductor device according to claim 31 or 32 which is at least one element chosen from P, N, As, Sb, and Bi.

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[Translation done.]